U. S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

INSTRUCTIONS & SPECIFICATIONS

FOR AERIAL PHOTOGRAPHING & PLANIMETRIC MAPPING

ROCKY MOUNTAIN REGION

DIVISION OF ENGINEERING

1940

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PREFACE

These instructions are not intended to compare or discuss the many various methods and types of equipment used in photographing from the air or the construction of planimetric maps, but are intended to be used as a guide for the personnel of Surveys & Maps section of the Division of Engineering, Forest Service, Region Two. As to the method adopted by this Region, all employees of the Surveys and Maps section who are assigned to the various types of this work are expected to perform their duties in accordance with these instructions. It is realized that due to the rapid advance made in this work, changes will have to be made from time to time in order to keep abreast of the times, but until such changes have been tried and adopted, these instructions will be followed.

Acknowledgement is made with thanks to all members of Surveys and Maps and the other members of Region Two for their valuable suggestions presented both in writing and in the open meetings held for discussion of these instructions.

J. E. KING
Chief, Surveys & Maps

S E C T I O N B

PURPOSE OF AERIAL PHOTOGRAPHS & PLANIMETRIC MAPS

The purpose of aerial photographs is to provide data of an accurate nature from which a detailed study can be made of National Forest lands regarding cover, erosion, fire hazards, topography, map data, and the accessibility of country in general administrative work.

The purpose of planimetric maps is to prepare a map on one uniform scale and base with sufficient accuracies whereby they will furnish the basic data for all maps needed in the administration of National Forest lands, such as base maps, administrative maps, fire maps, range survey maps, and timber survey maps.

S E C T I O N C

ORGANIZATION AND DUTIES

Efficient administration can only be obtained from an organization whose work is in close harmony and this cannot be accomplished unless each and every member of the organization understands his or her position in the organization as to responsibility and authority. To acquaint each individual with just what part of the organization he fills and where his line of duty falls and from where he will receive his instructions and to whom they will be given, the chart shown on Page C-10 has been enclosed. This chart is the organization of Surveys and Maps. Each activity engaged solely or in any part in the aerial photography or the preparation of planimetric maps is shown on this chart by clear, outstanding lettering. All other activities having no part in this work are included on the chart, but have been subdued in the printing. Each member can readily pick the position he fills, his relationship and where he fits into the organization and to whom he is accountable for his work

The following is an explanation of general responsibility and authority:

1. Chief, Surveys & Maps: In addition to his other duties, he is responsibile for the administration and technical control of all aerial photographs and construction of planimetric maps, acting under the general supervision of the Assistant Regional Forester in charge of the Division of Engineering.

2. Stenographer & Clerk: The stenographer and clerk will be under the direct supervision of the Chief of Surveys & Maps. In addition to handling all dictation and typing of correspondence for the section of Surveys and Maps, the Stenographer and Clerk will type all bills for cooperative agencies on aerial photography, cut stencils for and keep the photo indexes up to date, maintain a card record of all triangulation and traverse stations throughout the Region, maintain a card record of all bench marks and elevations, make forms 79-ab for all bills of lading covering shipments of film and materials, type expense accounts and Forms 43-R-2 for the field men, keep card record of Forms 3701 and 3702, type all reports for the Washington Office, prepare forms 1034 for all purchases made by the field men on Forms 877, prepare monthly flying time reports for contractors leasing planes, and maintain all correspondence pertaining to aerial photography and planimetric maps, and handle all stenographic and clerical work pertaining to aerial photography and planimetric maps.

3. Correlator: This position is functional and administrative, insofar as it is related to the correlation of all aerial photographing, whether cooperative or for the Forest Service, and includes the examination of all prints and flying to determine whether or not they meet the standard specifications, setting up priorities of all work pertaining to aerial photography, and distributing to the laboratory or drafting room materials to be worked on. This position functions directly under the supervision of the Chief of Surveys and Maps.

4. File, Property, & Record Clerk: This position is under the direct supervision of the Chief of Surveys and Maps. Inasmuch as a very small portion of the work in this position pertains to aerial photography and the construction of planimetric maps, there will be no detailed list of duties, but all photographs, map files, property and map records will be kept by this clerk.

5. Aerial Photographer: This position is one of the utmost importance, but due to the wide spread of work and the lack of contact each photographic crew will function as a separate unit and will be under the direct supervision of the Chief of Surveys and Maps. The photographer will be in charge of the flying crew at all times when away from the home base and it will be his responsibility to determine the days when photographing should be done and the number of hours to work; however, he will receive all orders from the Chief of Surveys and Maps as to the priority of projects and movements from one job to another. He will be furnished with prepared flight maps and given full instructions as to altitude and direction of flying, but will use his judgment as to the approach to work. All expense accounts, reports, etc. will be sent to Surveys and Maps.

6. Pilot and Photographic Ship: This position will be filled by contract and when operating from field base will be under the direct supervision of Position #5. Since photo-

graphing is only performed when weather conditions are at the best, there is very little or no responsibility connected with the flying as far as weather is concerned, but the pilot will be responsibile for all repairs and upkeep of the ship and will determine whether or not it should leave the ground. He must keep the photographer advised regularly as to the condition of the ship.

7. Laboratory Technician: In as far as this position is concerned with aerial photography and the construction of planimetric maps, the laboratory technician will act in a general supervisory capacity pertaining to laboratory work on aerial film, contact prints, ratio prints, enlargements, and copying. This supervisory capacity will be in the form of close cooperation between the laboratory facilities and the men assigned to work and the close correlation of all work. He will hold the photographer in position #8 responsible for administering the details of all work pertaining to aerial photography. This position is under the direct supervision of the Chief of Surveys and Maps.

8. Photographer: This position will receive working orders from Position #7, but will be directly responsible for the technical and immediate supervision of all laboratory work and workers pertaining to aerial photography. He will have directly under his supervision Positions 13, 14, 15 and 16.

Positions 9, 10, 11, and 12 have no connection whatsoever with aerial photography and planimetric mapping.

13. Processing of Aerial Film: This position is highly technical and pertains to the processing of all aerial film and the position is directly under the supervision of Position #8 at all times and will receive all orders from and be accountable to Position #8.

14. Contact Prints: This position requires a technical knowledge of the process of contact printing as it concerns the manipulation and processing of contact prints. All instructions are received from Position #8 and direct responsibility for the quality and quantity of the work done is to Position #8.

15. Ratio Prints & Enlargements: This position requires a technical knowledge of scale factors and of the processing and manipulation of bromide papers. All instructions are received from Position #8 and direct responsibility for the quality and quantity of the work done is to Position #8.

16. Copying: This position requires a technical knowledge of copying procedure and practice and is under the supervision of and is accountable to Position #8.

17. Field Engineer in Charge of Field Control: The engineer in this position will be directly in charge of all field control on projects assigned to him. He will receive all instructions from the Chief of Surveys and Maps and make all reports to same. His duties will consist of establishing control for planimetric maps and he must use his own judgment as to the approach and execution of this work

receiving general instructions from the Chief of Surveys and Maps as to the priority of work and any changes in assignment. In cases where it becomes necessary to have two or more parties working a long distance apart, each party will function as a separate unit.

18. Assistants: This position will assist only the field engineer and will receive all instructions from him. The position will be temporary and seasonal.

19. Chief of Drafting: This position is executive and administrative insofar as it pertains to work assigned to the drafting room. The Chief Draftsman is accountable to the Chief of Surveys and Maps only in all activities under his jurisdiction. Since a minor part of his work is directly connected with the construction of planimetric maps, he will assign all work except drafting to Position #20 and will be responsible for the general administration and the amount of work accomplished and the accuracy secured.

20. Cartographer, Assistant to the Chief Draftsman: This position will receive working orders from and be accountable to Position #19, but will be directly responsible for the efficiency and immediate supervision of both work and men pertaining to the construction of planimetric maps. He will have directly under his supervision Positions 22, 23, 24, 25, 26, and 27 and will assist in all phases of the work.

21. Draftsman, Assistant to the Chief Draftsman: This position has no connection with the construction of planimetric maps whatsoever and will pertain only to other phases of Surveys

and Maps activities. He will receive all orders and be responsible to Position #19 for all work.

22. Controlling Photographs: This position consists of picking radial control points, tie points, etc., and numbering same - in general, the correlation of all office-picked points with those established in the field in such a manner as to give the greatest amount of efficiency in the compiling of planimetric maps. This position may receive orders from either Position #19 or #20, but will be accountable to Position #20 for all work.

23. Making Templets: The duties of the draftsman in this position is to make templets from previously controlled aerial photographs for the use of laying radial line control and must be skilled in the use of a ruling pen. This position may receive orders from either Position #19 or #20, but will be accountable to Position #20 for all work.

24. Detailing Photographs: The duties in this position are the establishing of all detail clearly defined on the aerial photographs by inking this detail on the photograph under a stereoscope, making all detail photographs ready in final form for map compilation. This position may receive orders from either Position #19 or #20 but will be accountable to Position #20 for all work.

25. Photo Triangulation: This position is highly technical and requires a thoroguh knowledge of map compilation as well as an infinite amount of patience. It is

the cartographer's duty to establish a break-down net of control by the radial line method, using field triangulation as a base. This position may receive orders from either position #19 or #20 but will be accountable to Position #20 for all work.

26. Machine Transfer: This position requires a cartographer skilled in the art of compiling maps, the duties of which are to transfer and adjust by mechanical means all detail from aerial photographs to previously established radial control base and construct planimetric map in finished pencil form. This position may receive orders from either Position #19 or #20, but will be accountable to Position #20 for all work.

27. Land Lines and Editing: This position requires a cartographer with wide experience in map compilation. He will assemble and adjust all land lines to previously established control or map features on all planimetric maps, proof and edit map in final pencil form. This position may receive orders from either Position #19 or #20, but will be accountable to Position #20 for all work.

Positions #28 and #29 have no connection with the construction of planimetric maps.

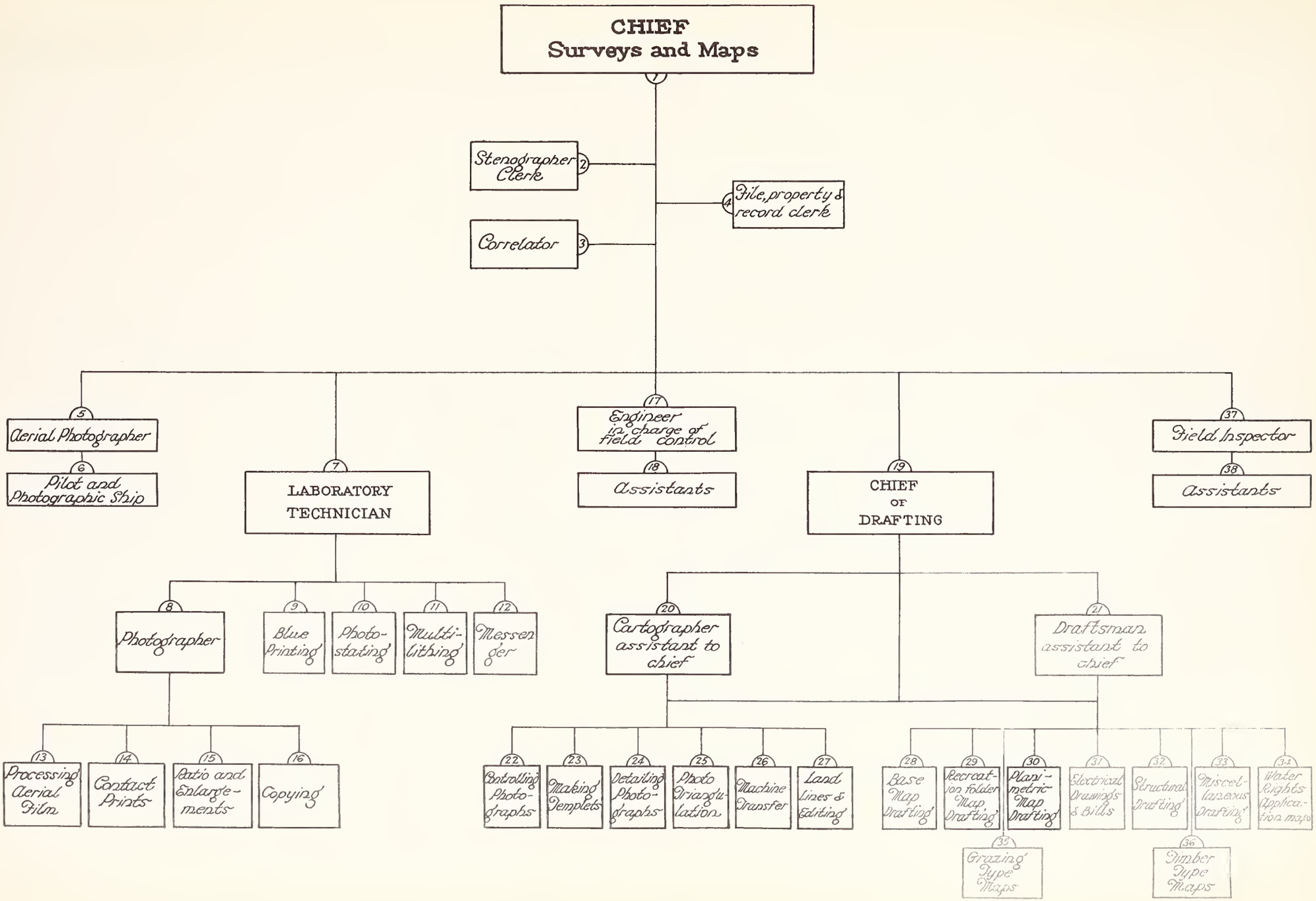
30. Planimetric Map Drafting: This position requires a draftsman with wide experience in map drafting. His duties will be to ink in final form the pencil copy of the planimetric map. He will not be required to compile any portion of the map.

This position will receive instructions from and will be directly responsible to Position #19.

Positions #31 through #36 have no connection with planimetric mapping.

37. Field Inspector: This position must be filled by an engineer who has the ability to make quick and accurate decisions, for it is his duty to check in the field and make the last and final analysis of the planimetric map. This position will receive all instructions from and will be directly under the supervision of the Chief of Surveys and Maps only. He will have one or more assistants as the work requires and will be assigned annual work by the Chief of Surveys and Maps.

38. Assistants: This position is temporary and seasonal and will receive all instructions from and be accountable to Position #37 for all work.


CHIEF
Surveys and Maps
1
Stenographer Clerk
2
Correlator
3
File, property & record clerk
4
Aerial Photographer
5
Pilot and Photographic Ship
6
LABORATORY TECHNICIAN
7
Photographer
8
Blue Printing
9
Photo-stating
10
Multi-lithing
11
Messenger
12
Processing Aerial Film
13
Contact Prints
14
Ratio and Enlargements
15
Copying
16
Engineer in charge of field control
17
Assistants
18
CHIEF OF DRAFTING
19
Cartographer assistant to chief
20
Draftsman assistant to chief
21
Patrolling Photographs
22
Making Templets
23
Detailing Photographs
24
Photo Triangulation
25
Machine Transfer
26
Land Lines & Editing
27
Base Map Drafting
28
Recreation folder Map Drafting
29
Planimetric Map Drafting
30
Electrical Drawings & Bills
31
Structural Drafting
32
Miscellaneous Drafting
33
Water Rights Application maps
34
Grazing Type Maps
35
Timber Type Maps
36
Field Inspector
37
Assistants
38

S E C T I O N D

APPROPRIATIONS & FINANCES

Appropriations for aerial photography and construction of planimetric maps are set up under the following designations:

P&M Regional Office, Surveys & Maps
CWTS, Surveys & Maps
CCC, Surveys & Maps

These funds are disbursed through the Regional Office only and all charges against them are made by the Chief of Surveys & Maps only with the approval of the Assistant Regional Forester in charge of the Division of Engineering. The Surveys and Maps appropriation is handled by a fund accounting system in the office of Fiscal Control and all encumbrances against this appropriation must be routed to Fiscal Control.

All field going parties travel on a per diem and expense account. These expense accounts are to be sent direct to Surveys and Maps where they will be checked and submitted for payment. All purchases made on Forms 877 will be handled in the same manner as expense accounts. Any miscellaneous expense such as labor and hiring of men will be handled on Forms 874-15 which will be signed and submitted to Surveys and Maps for payment.

Reimbursements from cooperative work will be billed by Surveys and Maps and credited to the Regional Office, P & M Surveys and Maps fund.

S E C T I O N E

EQUIPMENT

The Forest Service owns all equipment to perform the duties of aerial photography and the construction of planimetric maps, with the exception of the airplane which is leased under a yearly contract. There are two types of airplanes used under these contracts - one a plane with a photographic speed of 80 to 100 miles an hour and the other a plane with a photographic speed of 200 miles an hour. The only difference in the specifications are in the horsepower and the speed required. The following is a standard specification for a 200-mile an hour photographic speed ship:

"Airplane service with pilot for aerial photographic work for cover study and administration of National Forests, contract to be effective from date of acceptance until termination made in writing by the Government and not to exceed _____.

Rate per hour for flying time with oxygen $_____

Rate per hour for flying time without oxygen $_____

Bidder must enter here the make, type, horsepower, and full description of the plane he plans to use in meeting the specifications and conditions herein provided, and the name of the proposed pilots _____

_____

_____

"The airplane will usually be used to perform aerial photographic work and must be capable of performing all duties in accordance with these specifications. It must be a type commonly known as a bi-plane with motor of not less than a

450 H.P. rating, with a cruising radius of not less than 5 hours and capable of maintaining an even altitude of 23,000 feet above sea level when fully loaded for photographic work and have a speed of not less than 200 miles an hour at an altitude of 10,000 feet.

"The plane shall be adapted for the installation and effective use of a vertical aerial camera of the 9x9" precision type and vertical view finder mounted in suitable position.

The plane must be duly licensed by the Department of Commerce with an N. C. license and the pilot must be licensed and have not less than 1,000 hours of photographic flying over rough and mountainous country. In addition to the plane and pilot, the contractor must furnish all oxygen necessary for the crews, be responsible for and pay all the cost of operating and maintenance of all airplanes used as well as the expense of his personnel incident to the work and any rental or other charges that may be made for use of landing fields and transportation to and from landing fields. When on duty the plane will be expected to base at the nearest airport to the work being done, this being agreed upon by the contractor and Forest Officer. Oxygen equipment must be of the latest improved type.

"It is estimated that 200 hours of oxygen time and 100 hours of non-oxygen time will be required to accomplish this contract. Such flying will be done when the ground is free from snow and weather conditions are favorable. Flying time will be calculated in hours and minutes of actual flying. Field opera-

tions will be computed from the time the plane leaves the field base until it returns to the field base, or flying from one field base to another field base. Travel time at non-oxygen rate will be allowed when plane is ordered to field base and when ordered from field base to home base. The time allowed will be computed as that necessary to travel between Denver, Colorado and field base. At all times during the field operations the plane will be accompanied by a Forest Officer, who will be a photographer and a member of the crew. The plane shall be subject to the direction of the Regional Forester from the time the plane arrives at the field base until ordered to the home base by the Regional Forester. The term "Regional Forester" as used herein shall include any Forest Officer designated by the Regional Forester to act on his behalf.

"Payments will be made at the end of each calendar month or as soon thereafter as vouchers can be prepared for the flying time accumulated that month. When the plane is subject to the direction of the Regional Forester a payment of a minimum of $450.00 will be made for each month the plane is at the field base or a pro-rata amount thereof for a part of a month computed on a 30-day month. If, due to weather conditions, a sufficient number of hours of flying cannot be performed to entitle the contractor to payment of that amount at the hourly rate, the excess of such payment over the amount earned for the number of hours actually flown during each month at the rate per hour will be charged against

amounts earned during any subsequent month when the amount earned is in excess of $450.00 for the month. No right to payment shall accrue while the plane is not in readiness for flying or not under the direction of the Regional Forester.

"On each project, flight lines in excess of 5% thereof which do not meet the attached standard specifications for flying shall be reflown by the contractor at his own expense.

"The plane shall be in readiness for field flying with ten (10) days after notice by the Regional Forester to report for duty.

"The plane shall not be used while in the field for any purpose other than that requested by the Regional Forester, unless the constractor is given written permission by the Regional Forester.

"Neither the Regional Forester nor the United States of America shall be liable for any personal injury sustained by the personnel furnished by the contractor or other parties in connection with the work performed under these specifications and conditions, or for any injury sustained by any person, other than Forest Service employees, which results from the operation of the airplane or its equipment or for any damage to real or personal property which results from the operation of or accident to the airplane or its equipment.

"The contractor will not be held liable for any personal injury sustained by the personnel supplied by the Regional Forester in connection with the work performed under these specifications and conditions unless such injuries result from the wilful

act, negligence, or carelessness on the part of the contractor or his agent.

"The contractor shall hold and save the Government, its officers, agents, servants, and employees harmless from liability of any nature, or kind for or on account of the use of any copyright or uncopyrighted composition, secret process, patented or unpatented invention, article, or appliance furnished or used in the performance of this contract, excepting patented articles required by the Government in its specifications, the use of which the contractor does not control.

"If, in the judgment of the Regional Forester, the contractor shall fail to perform satisfactorily the airplane service required herein, this contract may be terminated by the Regional Forester.

"In accordance with paragraph 23, (b) of the specifications, a guarantee of ten percent (10%) of the estimated total amount of the contract at the bid price per hour shall be submitted with the bid.

"In accordance with Paragraph 24 of the specifications, a Performance bond shall be furnished by the successful bidder in an amount equal to twenty percent (20%) of the estimated total amount of the contract at the bid price per hour."

Aerial Film: Aerial film shall be of either an acetate or nitrate base and the following types are used in this Region:

Speed Group 50: Special Panchromatic Topographic;
9½" wide, 75 ft. long (18x24 cm)
with opaque leaders
9½" wide, 150 ft. long.

Speed Group 100:
9½" wide, 75 ft. long (18x24 cm),
with opaque leaders; Triple S
Panchromatic
9½" wide, 150 ft. long; Super XX
Panchromatic Topographic.

A complete stock of the following photographic paper and copy film will be kept on hand at all times, each individual project determining the kind of paper or film to be used:

Bromide Paper - Roll

EE-3, Semi-matte, double-weight, Medium 40"x10'.

Bromide Paper - Cut

EE-1, Semi-matte, Double-weight, soft, 20x24"
EE-2, " " , " " , brilliant soft, 20x24"
EE-3, " " , " " , Medium, 20x24"
EE-4, " " , " " , Hard, 20x24"

Bromide Paper - Cut

Glossy, Single-Weight, Normal Contrast, 8x10"
Glossy, Single-Weight, Medium Contrast, 8x10"
Glossy, Single-Weight, Contrast, 8x10"
Glossy, Single-Weight, Extra-Contrast, 8x10"

Chloride Paper - stocked in both 8x10" and 10x10" sizes:

Contrast	Grade
Extra-soft	SW Glossy F-0
Soft	" " F-1
Brilliant, soft	" " F-2
Medium	" " F-3
Hard	" " F-4
Extra-soft	DW Glossy FF-0
Soft	" " FF-1
Brilliant, soft	" " FF-2
Medium	" " FF-3
Hard	" " FF-4

Contrast	Grade
Extra-soft	DW Semi-matte EE-0
Soft	" " " EE-1
Brilliant, soft	" " " EE-2
Medium	" " " EE-3
Hard	" " " EE-4

Film in stock for copying:

Commercial - Panchromatic - 8x10"

Commercial - Orthochromatic - 8x10"

Sheets for Planimetric Maps: These will meet the following specifications:

Double mounted aluminum plates for drafting both sides; size 36x60". Plates - .025 to .030 gauge aluminum, grained on both sides in graining machine with porcelain marbles and 00 flint.

Paste - must be waterproof and non-oxidizing.

Papers - Keuffel & Esser's Paragon #22 or equal.

General - Plates must be mounted on both sides with the above materials and contractor must guarantee that no oxidation spots will occur under paper. Contractor will replace any or all such plates free of charge if oxidation does occur. Paste must be sufficiently waterproof to stand soaking the plate in water for 24 hours without the paper peeling off.

After mounting edges of plates must be taped with cloth tape; and paper must be re-sized for drafting; sizing must not be so soft as to pick up in ruling pen and neither must it peel off, but must go through the paper so that even after deep erasure a line drawn through the erasure will not be fuzzy.

The reference to the named makes are intended to be descriptive but not restrictive and only to indicate to prospective bidders articles that will be satisfactory. Bids on other makes or brands will be considered, provided that each bidder clearly states on the face of his proposal exactly what he intends to furnish, or forwards with his bid a cut or illustration or other descriptive matter which will clearly indicate the character of the article covered by his bid.

Plane Table Sheets: These will be the same as those for planimetric maps except that they will be 30x36" in size.

Control Tracings: These will be 36x60" in size and will be of a good grade of tracing cloth, cut to lie flat.

Templets for Laying Radial Line Control: These will be 7x9" or 9x9" in size and will be of five-gauge transparent plasticele.

S E C T I O N F

PHOTOGRAPHING

The specifications for photographing will be left out of these instructions due to the changing of cameras and lenses and to insufficient information on hand at present to make it possible to write detailed instructions; however, these will appear at a later date this year.

S E C T I O N G

CORRELATION OF WORK

General

The correlation of all aerial photographing and reproduction from aerial negatives becomes necessary when one or more photographic crews are maintained and operated from a central base, and particularly when cooperative work is entered into with other Regions or Government Agencies. Not only must a detailed record be kept on work performed, but a progress record must be kept from day to day of all flying and laboratory work, as well as a complete record of materials shipped. The man performing the duties of a correlator must be an energetic, alert, conscientious worker and have the faculty of dealing with others, as well as a sense of responsibility and the ability to designate work; he must also have a thorough knowledge of all types of photography and be able to judge the quality of all work, for it is his responsibility to receive all such work whether new or reproductions of old jobs, assign work to proper sections, establish priority and inspect all work before being accepted and shipped. Since all flying is done in this Region by our own crews, it becomes the correlator's responsibility to check all work to see that it meets specifications and reject all work that does not. The following is the procedure in which the work will be handled:

Aerial Film Received from Photographic Crew

This film will be received in the Regional Office by the mail room whether it comes by express or messenger and will be delivered promptly to the office of Surveys & Maps

where it will be opened by the correlator, who after reading the field sheets must determine whether or not any special conditions under which the roll was exposed would affect the order in which the rolls should be developed, also at the same time record all data received from the field (See Page G-9). When order for priority has been established, a requisition for photographic work will be filled out (See Page G-10). The film is then delivered to the reproduction office for complying with instructions. At this time a tag must be made showing film designation and number and placed on the progress board in the office of Surveys and Maps on the top row labeled "Received from Field."

As information is received from the laboratory that the film has been developed and has been printed, the tag is moved down the Progress Board to the appropriate rows to indicate the status of the film from the time it is received from the field until it is ready to be placed in the files or to be delivered to the cooperating agency. Status is also indicated by appropriate entries in the book "Progress Record of Aerial Surveys."

Checking Aerial Film for Coverage & Fulfillment of Specifications:

When the first set of check-prints (on brown-line paper) has been made from the new film, the prints and film are delivered from the laboratory to the correlator for checking as to the coverage and fulfillment of specifications.

The brown-line paper prints are cut into strips and labeled as to project, roll, and strip before the checking procedure is started. Ends of strips are indicated by blank exposures between

strips. The strips are next laid out in the manner in which they were flown as indicated by the flight sheet, and the detail is compared with the flight map to determine whether the strip has been flown in the correct place and is long enough. The first and last picture of each strip should fall entirely outside the project boundary.

At the same time, end lap is checked by noting detail appearing on alternate prints. Amount of end lap between adjacent pictures can be seen by comparing detail on these adjacent pictures. Adequacy of end lap for three-point intersections for radial line control may be noted by comparing detail on first, third, fifth, or second, fourth, sixth, etc. prints. End lap should be 60%, but should not be less than 55% nor more than 65%. Sidelap between adjacent strips is checked by comparing detail between these adjacent strips. Sidelap should be 30% but may not be less than 15% nor more than 45% except that in flying over country in which extreme variations in elevation exist, sidelap of 10% may be permitted if it is caused by elevation, and sidelap of 50% may be permitted if caused by terrain whose elevation is less than the mean elevation of the job.

Any series of three or more consecutive photographs in which the effective image area in the endlap area common to three photographs is reduced in any one photograph to less than 90% of the lateral dimension of the image area (as a result of any cause) may be considered unsatisfactory and

cause for rejection of that particular flight strip or any portion thereof.

No flight strip may be accepted which consists of fewer than eight exposures.

Tilt of any negative exceeding 4° or averaging more than 2° in any 10-mile section of a flight line or more than 1° for the entire project, or relative tilt between any two successive negatives exceeding 6° may be cause for rejection.

Flight strips shall be within 5° of north-south and the mean bearings of adjacent strips shall be within 5° of parallel.

Photographs showing a departure from the specified scale of more than plus or minus 5% in excess of that caused by variations in relief within the areas covered by the individual photographs may be rejected.

No strip or section thereof shall depart from its plotted location by more than 50% of the specified mean sidelap distance.

In case it becomes necessary to break a flight strip within the strip, the end lap at the break shall be not less than 100% and shall not be limited as to maximum endlap.

When a roll has been checked for compliance with specifications and for proper coverage, it is ready for lettering and placing in the files. Lettering is a procedure executed by the drafting department according to specifications outlined in the "Standard Specifications for Aerial Photography." It is the duty of the correlator to indicate on the brown-line strips the strip number, roll number, and negative numbers. This is done by indicating on the first and last exposure of the strip the information

required to be placed on that negative, that is, date, time, agency, scale, designation, roll, and negative number, in that order proceeding from left to right on the northern edge of the negative. All intermediate prints simply have written upon them the negative number. Lettering is done by placing the film upon the special light box designed for that purpose, according to the specifications outlined in Paragraph 14-a of "Standard Specifications for Aerial Photography A-AP-1101," using a Leroy Guide Number 175 and Pen Number 0, and numbering the negatives to correspond with the numbers placed upon the paper prints by the checker.

Each vertical negative is marked clearly with a designating symbol furnished by the cooperating agency or by the Washington Office of not to exceed four letters followed by the serial number of the roll and the serial number of the exposure on the roll (thus: ABC-116-110) and also with a numerical abbreviation of the month, day, and year of exposure (thus: 12-8-39). The rolls of film used in the performance of each contract, unless otherwise designated by the contracting officer, are numbered in an unbroken series beginning with number 1, and the exposures on each roll are numbered in an unbroken series beginning on each roll with number 1. The designating symbol, roll and serial number are placed in the northeast corner of each negative for the north and south flights and in the northwest corner of each negative for east and west flights, with

the exception of the control strips, in which case said symbol and numbers are placed in the upper right-hand corner of each negative, progressing along the line of flight. The abbreviation of the date is in each case placed in the adjacent corner in a counterclockwise direction, with the exception of the control strips, in which case, unless otherwise specified, it is placed in the adjacent corner in a clockwise direction. In addition, the first and last negative of each flight strip, at each break in each flight line, on the first and last exposure of each flight strip as shown on each index sheet, and on the first and last negative of each roll the initials of the Bureau or agency for which the work is being performed and the approximate scale of the negatives is placed immediately preceding the designating symbol and the serial numbers (thus: SCS -1:20,000-ABC-116-110), and the numerical abbreviation of the approximate time of day of the exposure is placed immediately following the date (thus: 12-8-39-12:30). The characters used in marking negatives are made with #175 Leroy Guide and O pen and are neatly drafted with celluloid ink, in such manner as to print clearly in positive form on the image area of the photograph in the position specified. The top of the characters must not be less than 1/8, or more than 1/4 of an inch from the image edges of the negatives.

After lettering of the roll all negatives not acceptable due to improper coverage or failure to comply with the specifications are stamped "Rejected" and the film is ready to be sent to the laboratory for whatever prints are to be made from it.

Spaces on the flight sheet indicating checking for coverage and lettering of the film are filled in as the work progresses by the person responsible for the particular function.

Miscellaneous Orders

All orders for reproduction work from aerial or copy negatives will be referred to the correlator; it will be his duty and responsibility to route this work through the proper channels and make complete record of progress. When such work is finished the shipping list will be filled out with complete instructions as to shipment, cost of work and form of billing required. This will be turned over to the clerk who in turn will send all orders out under letters of transmittal. Also in cases where partial shipments are being made, this must be noted and a complete list of each shipment must be kept.

Chemicals and Photo Supplies

These supplies will all be kept in the supply room for this purpose in the basement of the Post Office Building, for which the correlator will be custodian. He must keep a running inventory of all stock, make orders for supplies and distribute same upon requisition from the reproduction laboratory.

PROGRESS CHART FOR CO-OPERATIVE PROJECTS

Page ___ of ___

Bureau _____ Contract Date _____ Date Wanted _____ Project _____

Area to be photographed _____ Sq. Miles Photography Started _____ Photography Completed _____ Project Completed ____

MATERIALS TO BE DELIVERED _____

Roll No.	COMPLETE	DELIVERED																		
FILM			C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D
Received from field																				
Developed																				
Numbered																				
Number of negatives																				
CONTACT PRINTS																				
Rough set made																				
Rough set laid and checked																				
Rough set numbered																				
Extra sets																				
Glossy-staple mosaic																				
PROJECTION PRINTS																				
8x10 Rectified Mosaic																				
11x14																				
16x20																				
20x24																				
MOSAIC STAPLED Board No.																				
Laid																				
Copied																				
Projections-copy negative																				
MOSAIC-CONTROLLED																				
Laid																				
Copied																				
Projections-copy negative																				

REPORT TO WASHINGTON OFFICE
- Card form 3701 _____
- Card form 3702 _____
- _____ Large Scale Maps _____
- _____ Small Scale Maps _____

REPORT TO CO-OPERATOR
- Card form 3701 _____
- Card form 3702 _____
- _____ Large Scale Maps _____
- _____ Small Scale Maps _____

Remarks _____

6-9

E
Photography
Production

United States Department of Agriculture
Forest Service

Lab. Order No._____

REQUISITION FOR PHOTOGRAPHIC WORK

Charge to_____ Date_____
Send to _____ Date Desired_____
Approved by_____ Title_____ Requested by_____

CLASS OF WORK

___Develop Film_____ ___Make copy negative_____
___Contact Prints_____ ___Bleach Prints_____
___Projection Prints_____ ___Redevelop Prints_____
Enlargement Factor_____ ___Oil Coloring_____
Reduction Factor _____ _____

GROUND PHOTOGRAPHY

Size	No.	Price Ea.	Total Cost	Remarks	Init	Hrs	Date
4x 5 or less							
5x 7							
8x10							
10x12							
11x14							
16x20							
20x24							

AERIAL PHOTOGRAPHY

Designation	Roll No.	Negative Numbers	Init	Hrs	Date	Price	Cost

Weight
___DW
___SW
___PT

Surface
___SM
___Glsy

Drying
___Natl
___Pako
___Fero

Authorized
J. E. KING
Chief, Surveys and Maps

By_____

Designation _____

SECTION H

LABORATORY PROCEDURES

General

The photograph laboratory is located in conjunction with the reproduction plant, but functions as a separate unit within this plant under the general supervision of the laboratory technician, and the direct supervision of the photographer.

The photograph laboratory is equipped to handle the processing of aerial film, the making of all types of contact prints, ratio prints, and enlargements, as well as direct copy work. This will make up the majority of the work; however, from time to time, the photograph laboratory will be called upon to perform other types of photographic work, but the principle and most important jobs are those just mentioned. It is very important that no delay occur in these operations as the speed with which the work is turned out controls the movements of the flying crews.

All work will be delivered to the Reproduction Plant by the correlator with full instructions and the finished work must be returned to him.

The following instructions are to be used as a guide in all this work:

Developing

When Eastman aerial film is to be developed, use the following Formula D-19:

Water (about 125° F) ----------	64 oz.	
Metol----------		128 gr.
Sodium Sulphite (desiccated) ---------	12 oz.	360 gr.
Hydroquinone ----------	1 oz.	75 gr.
Sodium Carbonate (desiccated) --------	6 oz.	180 gr.
(monohydrated) --------	7 oz.	209 gr.
Potassium Bromide ----------		290 gr.
Cold water to make ----------		1 Gal.

When Agfa film is to be developed, use Agfa 30 formula, as follows:

Water (about 125° F) ----------	96 oz.	
Metol ----------		200 gr.
Sodium Sulphite (desiccated) ---------	8 oz.	
Hydroquinone ----------	1 oz.	80 gr.
Sodium Carbonate (monohydrated) ------	5 oz.	160 gr.
Potassium Bromide ----------		120 gr.
Water ----------		1 Gal.

Both of these formulas are high contrast, non-staining developers.

The developers are prepared in advance and are kept in gallon bottles. The developer is composed of Metol, Sodium Sulphite, Hydroquinone, Sodium Carbonate, and Potassium Bromide, and is mixed in warm water not to exceed 125° F. In dissolving the chemicals never add the second chemical until the first one is completely dissolved. Dissolve a small part of the Sodium Sulphite first, it acts as the preservative and prevents oxidation of the developer. The metol is then dissolved and it

acts as the reducing or developing agent, and gives low density with good detail. After the metol is dissolved, add the balance of Sodium Sulphite. After the sulphite is dissolved add hydroquinone which is also a developing agent like metol, except that it is slow acting, and gives great diversity and contrast without much detail. The combination of metol and hydroquinone form an excellent developing agent.

The sodium carbonate is then dissolved. It swells the emulsion and permits the developing agent to reach the silver salts and reduce them to metallic silver. Potassium Bromide is then added, and its purpose is to act as a restrainer and to prevent the developing agent from acting on the unexposed silver.

The film is developed in a Fairchild Automatic Developing Outfit, which consists of a motor drive, film drum, and three different sized tanks. The small tank is used for developer, the medium size for hypo, and the larger one for acid rinse bath and washing.

The first procedure for developing the film is to place the three tanks in a row. In the first tank, the large one, place water, in the second tank, the small one, place 3 gallons of developer, and in the third tank, medium size one, mix 32 ounces of Stock Hardner Solution to each gallon of 30% hypo. These solutions are to be used at a temperature of 65° F. It is a good idea to place these three tanks in a large tank which is filled with water at 65° F as it will help

to keep the solution at 65°F during development if the room is at a different temperature. Also measure out 13 ounces of Glacial acetic acid which is to be added to the tank containing water during development of film.

After the solutions are all ready the film is wound on the film drum in complete darkness. Particular care must be taken to get the film on the drum evenly so as to prevent the film from getting out of alignment during development.

Agfa film has about 6 feet of leader on each end, but Eastman film has leader on only the beginning of the roll so about 5 or 6 feet of leader must be spliced on the other end. The purpose of this leader is to prevent uneven development on the ends of the roll. The film is wound on the right side of the drum (the washer on the center rod of the drum indicates the front of the drum) with the emulsion on the outside. The film is then connected to the left side of drum and placed in the first tank which contains water and the film is wound over to the left side by hand. The film is wound tight enough to prevent the developer from going between the film. After the film is rinsed, place it in the developer and run it back to the right side by hand and then place on the motor and develop for specified time. The present time of developing is 12 minutes. While the film is developing add the acetic acid to the first tank. After film is developed, remove motor and place film in acid rinse bath and run through by hand. The end of the film that went in the developer first is to start through the acid bath first.

After the rinse bath the film is placed in the hypo for twice as long as it takes to clear. It is then washed for approxi-

mately one hour with about six changes of water. Use a Potassium Permanganate, Sodium Hydroxide solution to check for complete washing. If hypo is present the solution will change from purple to light amber. After washing the film is placed in a glycerine bath of 9 ounces of Glycerine to 3 gallons of water for ten minutes. The film is then wound on drying drum and chamoised.

Enough slack must be left when the film is drying so as not to stretch the film as it drys. After the film is dry, it is wound on a spool with the emulsion side out and placed in a can with identification on can.

Fixing Bath: Fixing bath (hypo) will be prepared in accordance with the following formula. This fixing bath is also prepared in advance in two containers. The 30 percent solution of hypo (sodium thiosulfite) is prepared in a 15-gallon crock. The acid hardening stock is prepared in a 5-gallon bottle:

KODAK - 5a

For films and plates

Water (about 125° F)	80 oz.
Sodium Sulphite (desiccated)	10 oz.
Acetic Acid (28% pure)	30 oz.
Boric Acid (crystals)	5 oz.
Potassium Alum	10 oz.
Cold Water to Make	1 Gal.

Add one part of cool stock solution slowly to 4 parts of cool 30% hypo solution, while stirring

hypo rapidly. A 30% hypo solution is made by dissolving 40 oz. hypo in one gallon of water.

The purpose of the hypo is to remove all the silver compounds which were not affected by light or developer.

The Acid Hardner Solution is made up of Sodium Sulphite which is used to protect the hypo from being decomposed by the acid and alum, and to prevent oxidation of the small quantities of developer brought over to the fixing bath.

The acid is used to stop the action of the developer immediately. Alum is used to harden the emulsion to prevent softening and swelling of the emulsion. Boric acid acts as an additional hardner.

Contact Printing:

The film is placed on the printer with emulsion side up, and then the metal guard is placed over the film on the right side to prevent developer from splashing on it. The lights in the printer are then adjusted so as to give an even illumination over the whole negative and to secure a print of uniform density. After the lights are adjusted, a grade of paper which will give as much contrast as possible without the loss of any detail is used to make the print.

The exposure shall be such that the proper density is secured in approximately the recommended developing time.

The developer used is prepared in stock solution and diluted with water as used. Prints will be developed to secure a uniform tone.

Highlights which do not show much detail can be improved by soaking print in water then spotting the highlights with concentrated developer or warm water. After development the prints are placed in an acid rinse bath (4 ounces of 28% acid to 64 ounces of water). The acid bath prevents stains and prolongs the life of the fixing bath. The prints are then fixed for about 15 minutes in acid fixing bath which is made up of 16 ounces of acid hardner to each gallon of 25% solution of hypo. Prints shall then be washed for approximately one hour or until no signs of hypo are left using Potassium Permanganate and Sodium Hydroxide test. Semi-matte prints are dried on drying rack. Glossy prints to be used for mosaics are to be glycerined in a glycerine bath of 2 fluid ounces of glycerine to 32 ounces of water for about 5 minutes then dried on rack. Glossy prints to be ferrotyped shall also be given a glycerine bath.

First print from new rolls shall have identification of job, roll number and print number in upper right hand corner on back of print and identification should be in far enough so it will not be cut off when print is trimmed.

Prints made on positype paper shall be fixed for from thirty seconds to one minute and washed for from 3 to 5 minutes. Washing longer than time specified might prove detrimental to the object desired, namely, minimum of shrinkage.

All finished prints shall be of uniform color and density and shall be of such a degree of contrast that all

detail of the negatives will show clearly, both in the shadows and highlights, as well as in the half tones between shadows and highlights. An adequate variety of grades of contrast paper shall be used in making prints to accomplish this purpose. All prints shall be free from chemicals, stains, blemishes, uneven spots, air bells, or streaks.

Projection and Ratio Printing

The lamp house on the projector is a mercury vapor square tube light. This light is five times faster than a 1000 watt Mazda and cooler than a 300 watt lamp, so the lamp is left burning while the operator is using the projector. The exposure is made by the use of a filter between lamp house and lens. The lens used for restitutional printing can be rotated and tilted. The projection board can be tilted or tipped for prints to be rectified.

When making enlargements or reductions that do not have to be rectified the enlarger and easel must be parallel, and focusing done at full aperture.

The amount of exposure depends on the density of the negative and size of enlargement or reduction. To find exposure make a test strip using different exposures. When the density of a negative is not even, dodging will be done to hold back the brighter areas while the denser ones are printed to insure an even print. The developer and developing time shall be that recommended by the manufacturer of the paper.

Prints that are to be made to scale shall have a certain amount allowed for shrinkage of the paper, which shall be determined by making tests, which are made by printing a measured scale on the paper before development and then measured when dried. The ratio or dimensions on points which are measured shall be correct within 2/10 of 1% (0.20%).

Prints to be used for mosaics shall be rectified according to templets which are made up in the drafting room. The control points should not be lettered too large on the negative. The prints shall be of even density and contrast. The prints shall be put in a glycerine bath of 2 ounces of glycerine to 32 ounces of water.

Prints which are made to scale shall be dried on drying rack where scale does not matter they can be dried in Pako.

Copying

In copying the photograph shall be flat on the copying board, which will be parallel to the focusing glass to prevent distortion. The light shall be placed as as to secure an even illumination and at an angle that none of the lights will shine in the lens. On glossy prints a cross lighting is best for it prevents halation and reflection of the lights on the prints.

The size of the reproduction depends on the distance of the camera from the copying board; the greater the distance the smaller the reproduction. To reproduce a photo the same size the distance will be approximately twice the

focal length. The film to be used for the copy will depend on the photo being copied and results desired. For copying line work a process type film is used which is sensitive to Ultra Violet, Violet, and Blue.

For black and white photos where half-tones are to be reproduced Commercial Ortho is preferred. Orthochromatic film is sensitive to Ultra Violet, Blue, Green, and portions of the Yellow. For copying color work where Commercial Ortho film will not reproduce the desired tones, Commercial Pan film is used - this being sensitive to all colors. The filter to be used will depend on the results desired and color sensitivity of the film. The action of a filter is to stop light of certain colors while transmitting other colors.

Red filter absorbs blue and green

Green filter absorbs blue and red

Deep blue filter absorbs green and red

Yellow filter absorbs blue light

The exposure of the film depends on the following factors:

1. Type of film used
2. Type of illumination (Ark or Mazda)
3. Density and finish of print being copied
4. Amount of reduction, or enlargement of copy
5. Lens aperture
6. Filter factor if filter is used

If an exposure meter is available, it will help to secure the correct exposure; if not, a film test can be made.

The developer used will depend on the film and results wanted. Process film will be developed in extreme high contrast developer.

Orthochromatic and Panchromatic film will be developed in D-19 if high contrast is desired. If low contrast with maximum detail is desired, use the following Eastman D-76 formula:

Water (about 125° F)----------	96 oz.
Metol----------	116 gr.
Sodium Sulphite (desiccated)-----	13¼ oz.
Hydroquinone ----------	290 gr.
Borax (gram) ----------	116 gr.
Water to make ----------	1 Gal.

Times of tank development of films for equal contrast with varying quantities of borax.

Borax Concentration Per Gal.

		Developing Time
Regular	116 gr.	20 min.
(5X)	584 gr.	15 min.
(7½X)	2 oz.	12½ min.
(10X)	2 oz. 294 gr.	10 min.

The films are then put through an acid rinse bath and then hypoed. Negatives are washed for about 1/2 hour

hour, then chamoised or wiped with damp cotton and hung up to dry.

Bleaching

The bleaching of a photographic print is a chemical reaction in which the silver metal is converted into Silver Chloride as follows:

Silver + Mercuric Chloride = Silver Chloride + Mercurious Chloride. Silver Chloride and Mercurious Chloride are both white insoluble substances so the print appears a milk-white color.

The formula used is:

60 ounces of water

6 ounces of Potassium Bromide

4 ounces of Mercuric Chloride

The purpose of the Potassium Bromide is to make the Mercuric Bromide more soluble.

After the print is bleached it should be washed thoroughly to prevent stains when it is redeveloped, and also prevent getting any of the bleaching solution on drying rack. If bleached print is to be redeveloped the standard developer for prints is used. When the developer is applied to the bleached print the Silver Chloride and Mercurious Chloride are reduced to Silver and Mercury Metal plus complex salts.

The operator should always wear rubber gloves during bleaching process. The bottle containing the bleach solution shall be labeled POISON.

S E C T I O N I

HORIZONTAL CONTROL FOR PLANIMETRIC MAPS

General

The establishment of horizontal control for planimetric maps must be executed with the greatest precision and care, for it is upon this control that the accuracy of the entire map is based; however, in this Region we have sufficient first and second order control previously established by the U. S. Geological Survey and the U. S. Coast & Geodetic Survey so that no consideration will have to be given in these instructions regarding these two classes of control. Since this Region lends itself well to plane table triangulation, only in extreme cases will traverse be considered for control and only in cases where there is not sufficient first or second or previously established third order control will third order triangulation be considered.

The man in charge of control must be an engineer with sufficient knowledge and experience to perform all the duties in the following instructions.

Third Order Triangulation

Since it is very doubtful as to the amount of this type of work to be used and it will only be used in extreme cases where there is not sufficient control previously established of this or a higher order, no detailed instructions will be given here. Should it be necessary to establish this type of control, the engineer should follow the U. S. Geological Survey instructions for established third order triangulation.

Third Order Traverse

This method of control should be avoided wherever possible due to its slowness and excessive cost. However, it may be found

necessary in some rare cases in this Region to establish third order traverse control for planimetric maps. Before undertaking this, the engineer should consider all possibilities of expanding his control by the use of plane table triangulation, even though it will necessitate the construction of towers. Should it be found absolutely necessary to establish a net of traverse control, the following instructions by E. M. Douglas as published by the U. S. Geological Survey should be followed:

General Conditions for Map Control

The boundary lines of all regular United States Geological Survey maps are parallels of latitude and meridians of longitude. In order that these shall be properly located and that intermediate points shall be placed in correct positions, some system of horizontal control is required. The method to be adopted for linear control should be fixed by the character of the country, one of the requirements being that all control work shall be so accurate that no errors will be apparent in maps several times as large in scale as those to be published. In mountainous regions or in hilly, partly timbered areas horizontal control is effected by a system of triangulation, the whole area being divided up into triangles whose apexes are represented by stations established on prominent points several miles apart.

In heavily timbered areas, where it is difficult to see from any point more than a mile or two in any direction, horizontal control is best obtained from distances measured on the ground with a 300 foot steel tape, a record being made of angles measured with a transit at each bend of the line. Such control must begin and

end at points whose positions have been previously determined, and regardless of the character of the country such control must be carried around the edge of each quadrangle and once across its center east and west.

The United States Board of Surveys and Maps has classified traverse control for geodetic or map use into four orders. The position check for the first order is 1 in 25,000; for the second order, 1 in 10,000; for the third order, 1 in 5,000. Control of the fourth order is based on tape, wheel, or stadia distance measurements. For transit-traverse control as executed by the Geological Survey for map use an accuracy of the third order only is necessary, but the limit of error of 1 in 5,000 must be maintained. The main or trunk-line traverses that supplement the first-order (precise) work of the United States Coast and Geodetic Survey must be of such an accuracy that a control point near the corner of each degree quadrangle shall be located with an error of not more than 1 in 7,500.

Transit-Traverse Field Work

Personnel and Outfit of Party:

A transit-traverse party consists of an instrument man in charge, a recorder, two tapemen, and two rodmen; also a cook and a teamster when camping is necessary.

The following supplies can be obtained on requisition:

One transit, graduated to 30 seconds and furnished with stadia wires.
Two 300 foot steel tapes, graduated to feet throughout.
One 100 foot steel tape.
Two red and white transit rods.
One stadia rod.

Two plumb bobs.
Eleven tally pins.
Three hand recorders.
Two electric hand lamps.
One tape repair outfit, punch, and rivets.
Three tape clips, temporary repairs.
Two tape holders.
One spring balance.
One thermometer.
One set steel dies, figures.
One set steel dies, letters.
Three large book bags.
Standard bench-mark tablets.
Canteens.
Cement (in cans).
Drills, hatchet, hammer, post-hole digger.
Transit-traverse field notebooks 9-928.
Tapemen's notebooks 9-929.
Blank notebooks 9-396, or 3 by 5 inch pieces of manila paper
Book of instructions.
Polaris and sun tables.

The instrument man must carry a reliable watch.

Adjustment of Instruments

Precautions: The object glasses and eyepieces of all instruments must be properly focused. The cross wires projected against a distant object should appear immovable when the eye only is moved. Before the adjustments are commenced the instruments must be firmly set up and leveled. An instrument may appear to be out of adjustment simply because some part is loose. The object glass may be partly unscrewed, or an adjusting screw may be only partly tightened; level bubbles or cross wires occasionally become loosened. Therefore, before commencing the adjustment of an instrument look out for such defects. When it is thought that an adjustment has been completed, always test it before using the instrument. All adjusting screws should be screwed tight enough to hold, yet not so tight as to injure the threads or put a severe

strain on any other part. Especial care should be taken not to strain the cross-wire screws. Adjustments should be made in the order given under the following headings, for some adjustments depend on the accuracy of others previously made, and a change in any one may affect the others.

Minor Repairs.

Setting of Bubbles. - For setting level bubbles a small supply of plaster of Paris should be kept on hand. For use the plaster should be mixed with water to the consistency of a thick paste. If plaster is lacking, strips of paper may be used, but these should never be jammed in very tight, as the pressure may distort the glass and thus vitiate the bubble reading by an appreciable amount. A reflecting surface of colored paper should be placed under the bubble in order to make the graduations more readable; a subdued green or blue tint is recommended.

Mounting of Cross Wires.

For mounting of cross wires a small bottle containing shellac dissolved in alcohol, a pinch of beeswax, and a pair of dividers or a forked stick are needed. The best spider web is, of course, a freshly spun one from a small spider, for this will be both clean and elastic; but as spiders are not always available, it is well to keep on hand a spider cocoon. Such a cocoon will furnish webs enough to last for years, although with age the threads become stiff and brittle and therefore more liable to break from a jar to the instrument. Most webs taken from grass or bushes are rough, coarse, and dirty.

To draw the reticule from the instrument, unscrew and remove the eyepiece slide; then take out two opposite capstan-headed screws and loosen the other two. Using the latter two as handles, revolve the scross-wire ring 90°, insert a pointed stick through the end of the telescope tube into a screw hole in the ring, and, using it as a handle, remove the other capstan screws and draw out the ring. To replace it in the telescope, reverse this procedure. When in place the cross wires should be on the side of the ring toward the eyepiece.

Having pressed a bit of beeswax to each prong of the dividers or forked stick, let a small web fall from the end of one of the prongs, or pick with it from a cocoon a single thread, pressing the thread into the beeswax, stretch the thread moderately, and attach to the wax on the other prong. If an old web is used, it should first be dampened by dipping in water for a few seconds. In place of the dividers or forked stick, small sticks or lumps of wax may be attached to the web about 2 inches apart. Place the web across the reticule, using a magnifier to insure its coinciding exactly with the marked lines. Put a small drop of shellac on each end and leave until dry.

Instruments such as the prism level, dumpy level, and transit, which are not provided with Ys or similar devices for adjusting the cross wires, may be put in close adjustment by means of improvised wooden or metal Ys.

Adjustment of transit.

Plate levels. - With lower plate clamped and upper plate loose, level carefully; revolve the instrument 180° on its vertical

axis and bring each level bubble halfway back to the center of the tube by means of the screw at one end.

Collimation. - Level carefully, sight on a point about 500 feet distant, raise or lower the telescope slightly, and note whether the vertical wire remains on the point; if not, loosen the capstan-headed screw and turn the cross-wire ring till the vertical wire will remain on the point when the telescope is raised or lowered. Clamp the instrument, set the vertical wire so that it cuts the point selected, transit the telescope by revolving it 180° on its horizontal axis, and select a second point 500 feet distant in the opposite direction from the first. Unclamp the upper plate, turn the transit 180° on the vertical axis, relevel if necessary, set it on the point first selected, and again clamp the plate. Transit the telescope, and if the vertical cross wire exactly bisects the second point its adjustment is perfect; if it does not, bring it one-quarter of the way back to the second point by turning the two capstan-headed screws on the sides of the telescope.

Standards.- Set up the transit near a tall building or other high object; after leveling carefully, point the telescope so that the vertical wire intersects a definite point about 60° above the horizontal, depress the telescope, and select a second point near the ground. Unclamp the upper plate, revolve the telescope and plate 180° on the vertical axis, clamp the plate with the vertical wire again cutting the upper point, and depress the telescope; if the cross wire intersects the lower point, the standards are in adjustment; if it does not, correct for one-half

the error by the screw underneath one end of the telescope axix.

Object-glass slide. - If an adjustment for the telescope object-glass slide is possible, it is made as follows: First make the collimation adjustment for a point about 300 feet distant, then focus on a point 1,000 feet or more distant and again on a point only 10 or 15 feet distant, transit the telescope, unclamp the plate, turn it 180° on the vertical axis, and reclamp. If the cross wire still cuts the distant and near points, the slide is in perfect adjustment; if it does not, correct half the error by means of the side screws that hold the slide ring in place. Next repeat the regular collimation adjustment and again test for the slide error; repeat both adjustments until no errors appear.

Eyepiece tube.- The eyepiece may be put into position over the cross wires by turning the screws that hold the eyepiece ring until the cross wires appear in the center of the field; an exact centering is not required.

Telescope level. - If there is a level attached to the telescope, it may be adjusted by the "peg method" after all other adjustments are made, as follows: Level the transit and bring the bubble to the center of the tube under the telescope. Take a reading on a leveling rod or pole 300 or 400 feet distant, which is held on a stake set firmly in the ground. Revolve the transit 180° on the vertical axis and after again bringing the bubble to the center set a second stake at the same distance as the first and at such an elevation that the rod or pole reading

is the same as on the first stake. The tops of the two stakes will then be at the same elevation. Move the transit 25 or 50 feet back of one stake and on a line with the other. Make the telescope as nearly horizontal as possible by means of the attached level, clamp it, and then take a reading on the rod held on the near stake and another reading on the distant stake. If the two readings agree, the telescope is horizontal; if they do not agree, turn the tangent screw so as to bring the cross wire while set on the distant rod nearly to an agreement; repeat the operation until an agreement is reached. The telescope is then level, and the adjusting nuts at the end of the level tube should be turned until the bubble is brought to the center.

Vertical Circle or Arc. - The screws holding the vernier for the vertical arc should now be loosened and the vernier moved until the reading is 0° while the telescope is still level.

General Requirements:

Location of Line. - Transit traverses should always be run in circuits or tied to points previously located. In a 15 minute quadrangle, in country where routes can be readily planned, traverse lines should follow as closely as possible the borders of the quadrangle to be controlled, not departing from them more than is necessary to keep on roads. If there is a choice of roads, select the one in an unmapped area. An additional east-west line should be run to bisect the quadrangle. In areas where the country will not permit this plan to be followed economically,

and where the selection of routes for the lines must be influenced by the location of highways, it will be necessary to plan the routes to meet the specific requirements.

Permanent marks. - In areas where topographic conditions permit a tablet, a concrete post must be placed as near as possible to each corner of each 15 minute quadrangle, one on each side halfway between the corners, one in the center of the quadrangle, and others at average intervals of 3 miles along other parts of the lines. All such marks must be stations on the lines and unless they have already been marked by a levelman, should be stamped "Trav. Station No. __" (numbered consecutively) and also with the year of survey and the initial letter of the traverseman's surname. In areas that can not be traversed according to the regular plan permanent marks must be established at intervals not greater than 3 miles.

In cooperating States the appropriate tablet must be used.

Where level bench marks have already been established along the route of survey, they should be tied to and stamped as above and thus made to serve as permanent marks on the traverse line.

It is desirable that every permanent point be tied to two or more witness or reference points, and the true azimuths, a sketch and the approximate or exact distance to each, with description, should be duly recorded in the notebook.

Sites for Marks. - The sites for permanent marks should be selected with great care and be at points where they may be used by levelmen as bench marks. It should be borne in mind that the value of the work depends largely on the permanence and the accuracy of the marks. Marks that are intended to be permanent must not be placed nearer than 15 feet to a wagon road or a railroad. They should not be placed on bridges, though these may be good places for temporary marks. A concrete post may be placed on the right of way line of a railroad or highway. The right of way line at the intersection of two roads is commonly an excellent site. The marks should not be placed near old buildings that may soon be torn down, enlarged, or rebuilt. The site selected should be a place where the mark will not be in the way of anyone and will probably not be disturbed for many years. Marks set in earth in exposed localities should be surrounded by mounds of earth or stone.

Concrete Posts. - Where solid rock or large boulders are not available, the most durable objects in which to place tablets are concrete posts. These posts may be made by contract, or if made in place, proceed as follows: Provide two or three heavy reinforcing wires of nearly the length of the proposed post, with ends bent over an inch or so; also a piece of conical sheet-iron pipe 12 inches long, 6 inches in diameter at one end and 8 inches at the other. Dig a hole 12 inches in diameter and 24 to 36 inches deep. The deepest holes are required in cold regions; a 24 inch hole is deep enough in regions where the ground seldom freezes. Place the reinforcing wires in the hole, and fill within 6 inches

of the surface of the ground with concrete consisting of one part cement, two parts sand, and three parts broken stone or gravel, well mixed and moderately wet; tamp well. Set the iron pipe, large end down, over the center of the concrete block so as to inclose the wires, and space them an inch or so from the outside. Fill the pipe with cement mortar, consisting of one part cement and two parts clean sand; tamp well. In the top of the post place a tablet flush with the rounded surface of the cement. Any marks to be added to the tablet should be stamped on it before it is placed in the wet mortar. The finished post should not project more than 6 inches above the original ground surface. The post when completed should be sheltered from the sun for several days. If a mark must be established in soft or wet ground proceed as follows: Drive a wooden stake 3 by 3 inches, or larger, as far in the ground as it will go without splitting. Saw off the top about 6 inches above the ground. Place a length of glazed drain tile 6 inches or more in diameter around the stake, with its flange end at least 12 inches below the surface of the water or ground. Fill the tile with cement mortar, round off the top slightly, and set a bench-mark tablet in the top flush with the surface of the cement.

Azimuth Marks. - Whenever practicable two or more reference marks should be established for each permanent mark, from which azimuths can be found for future use. These may be church steeples, cupolas or schoolhouses, water tanks, corners of large buildings, or any other prominent objects. If no well-defined objects are visible, copper nails in large trees 50 to 100 feet distant will

serve the purpose. The distances and the angles to nearby marks should be measured. A sketch helps the computer avoid errors in finished work. All reference marks and the azimuths to them must be described and reported, together with the computed results of the line.

Additional Points. - Besides the permanently marked points, a number of other points should be carefully located along the traverse, and these points should be specifically designated in the field notes. Of special importance are the crossings of boundaries of States, counties, and civil townships, and the locations of the principal crossroads, railroad and highway crossings, railroad stations, and township and section corners. Note should also be made of less important landmarks, such as road forks, mileposts, railroad switches, and stream crossings. These points should be so completely described in the notebook as to be readily identified.

Control for Airplane Photographs. - In view of the extensive use of airplane photography for mapping, all points on a traverse line that can be easily identified from the air must be located.

Maps are most successfully compiled from aerial photographs when the control traverses are run after the photographs have been made. By this arrangement routes for traverses that will most effectively control the photographs may be selected. It is absolutely essential that traverse points be located near each end and the center of an area covered by a tri-lens photograph in order to control it properly, and the chance of getting

such a combination of points is very much reduced if the arrangement of the areas to be photographed in the quadrangle is not first considered. This condition does not apply to single-lens photographs, for which the ordinary rules for the distribution of traverse lines may be followed.

Control points for aerial photographs should be selected with due regard to easy identification, and only such points are are clearly shown in the photographs should be chosen for computation. Gates, trees, wire fences, windmills, houses, and indefinite road intersections are unsuitable. Road forks, road intersections, well-defined angles in roads or streams, stream crossings that intersect roads at right angles, fence lines defined by a growth of trees or brush, sharp angles in woodland boundaries, and railroad crossings usually make good points for identification.

Level Bench Marks. - The work must if possible be so arranged that the levelman can determine an elevation for each traverse mark; therefore the party that precedes should endeavor to select sites for marks suitable for the other party, and the descriptions made by both parties should agree. Copies of the descriptions should be forwarded daily to the party following.

Land Survey Corners. - Diligent search and inquiry should be made for marks on the public-land surveys, and the accurate connections should be made with each one that is found. It is very important that numerous corners be located for the topographer. In areas where unusual difficulty is experienced in finding corners, the General Land Office will, on request through

the Washington Office detail a cadastral engineer to assist in the search.

Accuracy. - For all circuit closures in new work or ties between located points of the same or a higher order an accuracy of not less than 1 in 5,000 (about 1 foot to the mile) must be maintained.

For main or trunk control traverses that follow routes near the borders of each full degree quadrangle an accuracy of 1 in 7,500 must be maintained - that is, the initial and computed positions of a tie points must not show a difference of more than 1 part in 7,500 of the length of the traverse line. To insure such a degree of accuracy especial care must be taken in making the measurements of distance. The front tapeman should be a man of experience and should be held responsible for proper procedure.

Highway Surveys. - Highway surveys may often be substituted for or used as transit traverse lines. The field notes for these surveys are usually obtained from the office of the State Highway Department, which is generally at the State Capitol.

The methods of surveying highways are similar to those used in transit traverse, except that the true azimuths of the lines are seldom given; but approximate azimuths may be based on a magnetic bearing of the first course, to which has been applied the deflection angle at each transit station. If no true azimuths are known, it will be necessary to tie to at least two adjacent stations near the beginning of each highway survey and to observe for the true azimuth of that course. Additional azi-

muths should be determined at stations not more than 10 miles apart.

Field notes of highway surveys should be copied in book 9-928. In these notes each station is usually referred to two or three points; the descriptions of these points should be copied from the field notes, and used in tying to the stations at which azimuth observations are to be made.

The results of each azimuth observation should be computed in the field as soon as the observation is made, and the bearings from the highway surveys should be checked between observations.

In copying field notes of highway surveys all road forks, bridges, railroad crossings, civil boundary lines, and junctions with other highway surveys should be noted for computation.

Highway surveys must always be tied to triangulation or transit-traverse stations by running a traverse line from a station on the highway survey to a station of higher order.

Field Methods:

Duties of Tape Men. - The front tape man must carefully mark off each tape length, if on a wagon road, with tally pins; if on a railroad tangent, with keel on the rail. Each time he marks off a tape length he registers it on his hand recorder; each time the rear tape man reaches the mark left by the front man he does likewise. When a transit station is established the two tape men compare their hand records for check on the measurement. Should they differ, the course must be remeasured.

Transit stations should be made at even lengths or even 10 foot marks, whenever possible, in order to simplify the work of the computer. They should be selected at points affording not only an unobstructed view back to the transit, but also a clear view forward. Each station is to be marked, if on a wagon road, by a 10 penny nail driven into the ground through a piece of paper on which the front tape man has written the number of the station and the distances; if on a railroad by a keel cross on the rail with the number and distance on the nearest tie.

Stations on main lines are to be numbered consecutively beginning with zero; those on short spur lines to section corners or other points to be computed are to be lettered instead of numbered. Station numbers should never be duplicated in a single locality.

The two tape men must keep in book 9-929 separate records of the number of stations and distances between them. At noon and at night these records must be compared with the recorder's notes and should there be a difference it must be corrected before the line is carried forward, the line being retraversed if necessary.

In locating transit stations the front tape man should bear in mind that it is desirable for the instrument man to be able to sight the bottom of the rod in each direction. This is especially important on short sights, for errors due to sighting the upper part of a rod which may be out of plumb may appreciably affect the accuracy of the line.

Method of Measuring. - When measuring along a wagon road the tape must be kept horizontal unless the grade is very slight; on short steep slopes a plumb bob must be used either to bring the tape end vertically over an established point or to establish a new point. Judgment should be used in selecting the proper length of tape on short slopes; no attempt should be made to use the full 300 foot length; about 150 feet is ordinarily all that a tape man can hold horizontal with the proper tension and plumb at the same time. On slopes that require "breaking" the tape into short sections, the entire tape should first be drawn forward its full length by the front rodman if convenient, or by the front tape man, who then returns to help "break" the tape at the proper places, until the end of the tape is reached. In this manner the distance is measured on the whole tape and does not depend on the sum of separate horizontal measurements.

On long regular slopes the distance on the slope should be measured and recorded and the angle of slope measured with the transit. The corrections for slopes of 1° or 2° for short distances are negligible.

Test of Tape. - A tested tape will be supplied to each party and should be kept in reserve; the tape used in measuring should be compared with the tested tape each week and the results made a part of the record. A tape when in use should always be stretched by means of a spring balance to a tension of 20 pounds.

Tape errors. - Tests of tapes by the Bureau of Standards seldom disclose errors as great as 0.01 foot in 300, but occasionally for a patched tape the error runs as high as 0.06 foot. Great

care should be taken when a broken tape is patched to see that the length of the section is not changed. Before any tape is used in the field the length should be checked up by the chief of party, by comparison with an unbroken standardized tape.

A difference of 7-3/4 feet in the elevation of the ends of a 300 foot tape will shorten the horizontal distance 0.1 foot. A difference in the elevation of 2-1/2 feet will shorten the distance 0.01 foot.

Geological Survey 300 foot steel tapes are standardized at a temperature of 68° F. and a tension of 20 pounds. A variation of 10° above or below this temperature will change of of length of the tape 0.02 foot. Differences of temperature of 20° or 30° above or below 68° are common and for such differences corrections should be made in the recorded figures for distances, which should be increased for temperatures above 68° and decreased for temperatures below 68°.

A change in tension of a Geological Survey 300 foot steel tape from 20 to 25 pounds increases its length 0.016 foot. A decrease in tension from 20 to 5 pounds shortens the tape 0.047 foot.

The correction for sag (always negative) for a 300 foot tape supported at 50 foot intervals under a tension of 20 pounds is 0.016 foot.

Errors in Taping. - The errors that most seriously affect the accuracy of taped lines may be grouped in two classes.

The errors of one class are due to failure to keep the tape horizontal and to careless plumbing. The instrument man

should impress the tape man with the fact that the accuracy of traverse depends on the taping more than on the instrumental work, for the latter is checked at every azimuth observation, whereas there is no check on the taping until the circuit is closed.

The errors of the other class are gross mistakes, arising generally from carelessness in counting tape lengths. They may be eliminated by checking the count of tape lengths by independent measurements. To do this, the instrument man should measure each distance by stadia, using the red and white transit rod or a special stadia rod carried for this purpose. In case the distance is too great to be read by a single sight, he should set up the transit between stations and read both front and rear rods. Stations should under no circumstances be more than 2,600 feet apart, which is about the limit of visibility of the rod. On a railroad an additional check on the taping may be had by counting rail lengths, but it should be remembered that rails may be 26, 28, 30, or 33 feet long. The counting should be done by both rodman and the recorder, or by the instrument man while moving from one station to the next. In other places a check may be had by pacing. The distance to a plus point should be checked, as well as the distance to the next station.

Temperature record. - The transit man should carry a thermometer and record the temperature every hour.

Stadia Control. - Under certain conditions it is allowable to substitute stadia distances for tape-line measures in transit traverses for "fourth order" control of maps. Such lines should

not exceed 20 miles in length and should be well checked, either by tying to a previously determined point or by closing on an azimuth station. Points on statia lines should not be used as initial points for the extension of transit traverses.

For work of this class a Philadelphia rod with two targets should be used, one target to be fixed at the 2 foot mark, the other target to be set from signals by the transit man.

The value of the stadia interval must be accurately determined for each transit by the following method: With a steel tape measure a base line on nearly level ground and mark stations at intervals of 100, 200, 300, 500, 700, and 900 feet from the center of the transit. With the transit at station 0 read and record the rod interval at least five times for each station, setting the upper target carefully for each reading and recording intercepts to three places of decimals. Repeat the observation at intervals of two hours from 8 A.M. to 4 P.M. The means of the differences between the steel-tape distances and those found by stadia will be the corrections to apply to stadia readings before recording them. Only the corrected stadia distances are to be recorded.

Stadia stations should not be more than 900 feet apart.

OBSERVING AND RECORDING.

Deflection Angles. - At each station, in reading deflection angles, the instrument man should proceed as follows: Sight rear rod with transit circle set at last reading at previous station, transit telescope, sight front rod and read both verniers. Turn instrument with the two plates clamped, the vernier remaining

undisturbed; sight rear rod again and remeasure the angle. If the two results thus obtained differ more than 60 seconds, repeat the operation. Opposite vernier readings will not always give the same minutes and seconds; both must be read and recorded to the nearest second.

When the transit is carried from one station to the next, keep the upper plate clamped so as to retain the last vernier reading; after setting up the instrument verify the reading and record it as the first back-sight reading at the new station, but both verniers must be read twice at each station. By following this plan a useful check on the readings is procured without trouble, and it also permits easy and quick computation of an azimuth at any station. The approximate azimuth of a line must be known at a station where daylight observations are to be made on Polaris, in order to determine the proper pointing for the star.

Computing Azimuth. - If the foregoing rule has been adhered to, the azimuth of a line at any station at which the deflection angle is read twice only may be found as follows:

Find the difference between the A vernier reading for the last foresight along a preceding course the azimuth for which is known and the A vernier reading for the last foresight along any following course the azimuth of which is desired; subtract the smaller reading from the larger and divide the difference by 2. Adding the quotient to the known azimuth when the later A vernier reading is greater or subtracting it from the known azimuth when the later A vernier reading is less will give the azimuth desired.

Example: At station 10 the last A vernier reading of foresight from station 10 to 11 is 120° 42' 00". At station 72 the last A vernier reading of foresight from station 72 to 73 is 94° 20' 00".

The azimuth of line 10 to 11 is 167° 25' 00".

120° 42' 00" - 94° 20' 00" = 26° 22' 00".

½ of 26° 22' 00" = 13° 11' 00".

Known azimuth 10 to 11	=	167° 25' 00"
	-	13° 11' 00"
Azimuth of line St. 72 to 73		154° 14' 00"

The half angle is subtracted in this example because the second vernier reading is less than the first.

Tangents. - At a railroad or highway crossing where there is a long tangent the distance to the farther end of the tangent should be assumed or estimated and the deflection angle to it recorded. In the computed results the record should be made according to the following model: "Position of a point 3 miles distant, on line with R. & N. Railway tangent, latitude 47° 10' 20", longitude 110° 14' 07"." This record will afford data by which the topographer can accurately plot the tangent.

Azimuth Observation. - Observations on Polaris or the sun for azimuth must be made each day if the weather permits. On a crooked line with many short courses azimuth observations should be made at points not more than 100 stations apart; on a traverse with long tangents they should fall not more than 10 miles apart. When practicable an azimuth station should be placed at each decided change in the direction of the line and where an abrupt change occurs between long and short sights. These requirements

may necessitate going back over the line in order to make the essential observations. If conditions are favorable it is possible to make azimuth observations on Polaris in broad daylight.

Both the transit and the azimuth mark must be at stations in the traverse preferably not less than 500 nor more than 1,500 feet apart. Each point should be marked by a stake with a tack or, if on a railroad, by a nail in a tie. The azimuth mark for night observations may consist of a vertical slit one-eighth inch wide and 6 inches long cut in the side of a box or tin can containing a candle or lantern, the slit to be carefully centered over the tack in the stake, or of a nail on the marked point illuminated by a lantern or flashlight shaded from direct observation from the transit.

In pointing the telescope for night observation use the electric hand lamp to illuminate the cross wires, holding it nearly in front of the object glass, or allow it to shine on a piece of paper fastened with a rubber band in front of the object glass and having in it a half inch hole.

In clear weather Polaris can be seen with a good transit telescope several hours before sunset, but it is necessary to know the star's altitude within about 10 minutes of arc and its bearing within about 1° in order to get the star into the field of the telescope when it is not visible to the naked eye. The finding of Polaris in daylight may be facilitated by preparing a table of positions of the star for a month in advance. The table should give the hour angle for a selected hour of local time, also the altitude and azimuth of the star for the same time.

Corrections easily applied may be found for other hour angles and for changes in latitude and longitude.

To find the altitude and azimuth with sufficient accuracy for this purpose proceed as follows:

Assume that an observation is to be made at 3 hr. 25 min. P.M., ninetieth meridian (central) standard time, January 10, 1925, at a place whose latitude is 40° 10' and longitude 85° west from Greenwich, as scaled from a good map. As 85° is 5° east of the ninetieth meridian the watch is five-fifteenths hour, or 20 minutes, slower than local time. The observation is therefore to be made at 3 hr. 45 min. local mean time.

The ephemeris shows that the nearest upper culmination of Polaris, which is then on the meridian above the pole, occurs at 6 hr. 15.6 min. P.M. January 10, 1925, Greenwich mean time. The correction to reduce this culmination time to 85° west longitude time is -0.9 min.

Local time of upper culmination 6 h. 15.6 m - 0.9 m.	$6^h\ 14.7^m$
Assumed observation time	$3\ \ 45$
Hour angle of Polaris	$2\ \ 29.7$

Always take the nearest upper-culmination time, whether it is before or after the observation time.

From the table on page 22 of the United States Geological Survey Bulletin 650 the bearing of Polaris for latitude 40° 10' and an hour angle of 2 h 29.7m (before upper culmination) was found to be 0° 53' 07". Polaris was therefore about 53' east of true north at the time and place of observation. This is not the exact bearing but it is near enough for the purpose. When this table is not at hand the bearing can be computed from the table on

page 10 of the ephemeris.

The altitude of Polaris may be found from the tables on Page 26 of Bulletin 650. It may also be found by reversing the operation called for by the tables on page 12 of the General Land Office ephemeris or by means of the following formula:

Sine of altitude = $\sin\phi \sin\delta + \cos\phi \cos\delta \cos t$ where ϕ = the latitude of the place, δ the declination of the star and t its hour angle east or west of upper culmination.

With the transit in good adjustment set off on the vertical arc an angle of 41° 03' (the altitude); next focus the telescope very carefully for a distant pointing. It is well to focus the telescope on a star at night and then mark the focusing slide so that it can be set at the same place any time, for unless the telescope is properly focused the star can not be found in the daytime.

If an approximately true north bearing is not known, obtain it by compass, making proper allowance for declination. Point the telescope 0° 53' east of true north, as found by computation or by the needle. If the air is clear and the star cannot be seen in the field of the telescope, turn the transit on its vertical axis slowly, without disturbing the vertical-circle setting, for a degree or two to the right of left to correct any imperfect pointing in azimuth. When the star is seen turn the tangent screws of both the vertical and the horizontal axis so that the cross-wire intersection will cover it, and then proceed with the observation for azimuth in the manner described below, which is applicable to observations at any hour of the day or night when the star

is visible.

Angles may be read as follows: Set on azimuth mark, then on star; reverse telescope; set on star, then on azimuth mark, each set of observations should consist of not less than three direct and three reverse measurements, the circle being shifted for each set by about 60°. Observations may be made at any time the star is visible, but preferably when it is at or near elongation. The time of setting the cross wires on the star should be recorded to the nearest second. Observations should be made rapidly; not more than 15 minutes need be taken to complete a set. The notes should be kept in the form which follows:

Date: January 10, 1925
Azimuth observation at station 332, mark at station 333.
Latitude 40° 10', longitude 85° west of Greenwich.
Watch 35 seconds fast of ninetieth meridian stardard time
(not daylight-saving time).

	Vernier A	Vernier B	Mean	Angle Mark: to star	Watch Time
	° ' "	° ' "	° ' "	° ' "	H. M. S.
Mark	279 06 30	99 06 00	99 06 15	--------	----------
Star	333 02 30	153 03 00	153 02 45	53 56 30	3 40 18
Star	153 01 30	333 01 00	153 01 15	53 55 45	3 41 20
Mark	99 06 00	279 05 00	99 05 30	--------	----------
Mark	172 02 00	352 02 30	172 02 15	--------	----------
Star	225 56 00	45 56 00	225 56 00	53 53 45	3 45 00
Star	45 56 00	225 54 30	225 54 45	53 52 30	3 46 45
Mark	352 02 30	172 02 00	172 02 15	--------	----------
Mark	40 56 00	220 56 00	40 56 00	--------	----------
Star	94 46 30	274 46 30	94 46 30	53 50 30	3 50 19
Star	274 46 00	94 45 30	94 45 45	53 49 30	3 52 36
Mark	220 56 00	40 56 30	40 56 15	--------	----------
Mean:				53 53 05	3 46 03
Watch Fast					35
					3 45 38
					2 45.5

Because of the difficulty of finding Polaris for daylight observations, it is often advantageous to record the reading on the star first, then on the mark and last on the star.

For daylight observations when the star is only dimly seen it is not advisable to shift the horizontal circle between readings, as to do so would make it more difficult to find the star again.

On the same page with other records the latitude and longitude of each azimuth station, scaled to the nearest minute from the best map available, should be recorded, together with the date of observation, the watch error, and a statement as to the time zone used and whether or not the watch was set for daylight-saving time.

An example of computation for either daylight or night observations on Polaris is here given;

January 10, 1925, ninetieth meridian time. Latitude 40° 10', longitude 85° 00'. Instrument on station 332, mark on station 333.

	H.	M.	S.
January 10, 1925, ninetieth meridian standard time of observation (correction having been made for watch error)	3	45	28
Correction for 5° east of longitude 90°	+	20	00
Local mean time of observation	4	05	28
		(4	05.5)

The nearest upper culmination of Polaris as given in table is $6^h\ 15.6^m$ P.M. January 10, 1925, Greenwich mean time, civil date. The correction (always negative) to reduce to local meridian is 85/360 of daily change (3.9^m) 0.9^m

	H.	M.
Local mean time of upper culmination, January 10, 1925 P.M. ($6^h\ 15.4^m\ 0.9^m$)	6	14.7

	H.	M.
Hour angle, being the interval between time of observation (4^h 05.5^m) and time of culmination	2	09.2
With this hour angle as an argument and the declination for the given date 88° 54' 25", find by double interpolation from the table of azimuths of Polaris of the Land Office tables (p. 10) the azimuth angle for the latitude and time	0°	46.9'
As the star has not reached culmination it is east of north 180° or, 180° being added, has an azimuth of	180°	46.9'
Subtract from this angle the measured angle between mark and star	53	53.1
The star being east of the mark, the remainder is true azimuth of the mark on station 333 from station 332	126	53.8

A rough check of this azimuth may be obtained by comparing it with the observed magnetic bearing, allowance being made for declination.

Sun Observations. - When it is impracticable to take observations on Polaris for azimuth, observations on the sun may be taken instead, but such observations should not be taken within two hours before or after noon, or when the vertical angle of the sun is less than 15°.

Set up the transit at a station in the line of survey, adjust and carefully level it, read the verniers and record the readings for first pointing on the rod. Point the telescope to the sun and allow the image to fall on a piece of white paper held 3 or 4 inches from the eyepiece. Focus the cross wires on this image. By means of the two tangent screws move the telescope till the vertical and horizontal wires bisect the sun's image, taking care to use the middle horizontal wire and not the upper

or lower stadia wire. Read and record the horizontal and vertical angles. Repeat the pointing and reading at least five times, and after the last pointing read again on the rod. Should the reading on the rod not agree within 1 minute of the first reading, discard the entire set and make new observations.

Reverse the telescope and repeat the readings at least five times as before. This time should be recorded to the nearest minute at the first and last pointing, and the mean time should be computed.

An example of field notes for afternoon observations is as follows:

Instrument, station 624; rod, station 625.
Latitude 38° 53' 46" (as scaled from any good map).
Date, November 10, 1925, ninetieth meridian time (standard time).

	Vernier readings						Vertical angles to sun		
Rod	0°	00'	00"	180°	00'	00"			
Sun	90	36	00	270	36	00	17°	01'	time of first pointing at sun 3^h 16^m P.M.
Sun	90	45	30	270	45	30	16	54	
Sun	90	55	00	270	55	00	16	46	
Sun	91	02	00	271	02	00	116	40	
Sun	91	09	00	271	09	00	16	35	
Rod	00	00	00	180	00	00			
	Reverse telescope (relevel if necessary).								
Rod	0°	00'	00"	180°	00'	00"			
Sun	91	30	30	271	30	30	16°	15'	
Sun	91	38	00	271	38	00	16	10	
Sun	91	45	00	271	45	00	16	04	
Sun	91	54	00	271	54	00	15	59	
Sun	92	00	30	272	00	30	15	52	time of last pointing at sun $\frac{3\ 20}{6\ 36}$ P.M.
	913	15	30				164	16	Mean time of observation 3^h 18^m

Mean Angle, rod to sun, + 91° 19' 33".

Mean of vertical angles	16° 25' 36"
Correction for refraction (always minus)	03 14
Correct altitude of sun	16 22 22

Refraction tables are given in Bulletin 650, page 334, but if no tables are available the approximate value of the refraction in seconds may be taken as 58 times the natural cotangent of the sun's observed altitude.

To compute the azimuth from the field notes use the formula:

$$\text{Cot}^2 \text{ Azimuth angle} = \frac{\text{sin of (S-latitude) x sin (S-altitude corrected for refraction)}}{\text{cos S x Cos (S-polar distance)}}$$

in which S= 1/2 (latitude + altitude + polar distance).

It is necessary to obtain from tables, for the hour, day, and year the declination of the sun - that is, the angular distance of the sun north or south of the equator. The declination at Greenwich noon, for each day in the year, is given in a publication of the General Land Office entitled "Ephemeris of the Sun and Polaris." This ephemeris is issued about December 1 of each year for the following year.

The polar distance is the angular distance between the sun and the north pole. In winter, when the sun is south of the equator, the polar distance is 90° plus the declination; in summer, when the sun is north of the equator, it is 90° minus the declination. Twice a year, September 23 and March 21, it is 90°, the declination being 0 when the sun crosses the line.

The procedure to find the declination of the sun in the example given is as follows:

Observations for November 10, 1925, 3^h 18^m P.M., ninetieth meridian time. When it is noon at Greenwich it is 6 A.M. on the ninetieth meridian (90° ÷ 15 6; 12 noon - 6 hours = 6 A.M.). The mean of the times of observation is 3^h 18^m P.M., 9 hours and 18 minutes after 6 A.M. local time or Greenwich noon. In the tables showing the position of the sun for the year 1925 the apparent declination at Greenwich noon on November 10 is given as 17° 04' 43" south. The south declination is increasing at the rate of 42.37 seconds for each hour after Greenwich noon. The tables give declination for apparent (sun) time. The change from apparent to mean noon can generally be disregarded, as it will never be more than 15 seconds of arc.

The observation was made 9 hours and 18 minutes (=9.3 hours) after Greenwich noon; therefore the change in the declination of the sun since the preceding Greenwich noon was 42.37x9.3 = 394 seconds = 6 minutes and 34 seconds.

Declination (south) November 10, 1925 at Greenwich noon	17°	04'	43"
Correction to be added for 9.3 hours		6	34
Declination at 3:18 P.M.	17	11	17

To find the polar distance, add the declination as above found to 90°: Declination	17°	11'	17"
	90	00	00
North polar distance Nov. 10, 1925 3^h 18^m P.M.	107	11	17

To find the value of S in the Formula:

Latitude	38°	53'	46"	
Altitude of sun	16	22	22	
Polar distance	107	11	17	
	162	27	25	
1/2 of sum	81	13	42	S
S	81	13	42	
Latitude	38	53	46	
	42	19	56	S-latitude

S	81°	13'	42"	
Altitude	16	22	22	
	64	51	20	S-altitude of sun
S	81	13	42	
Polar Distance	107	11	17	
	25	57	35	S-polar distance

There are times when the polar distance is less than S, but always subtract the lesser quantity from the greater.

All the quantities required in the formula are now known except cot azimuth angle. To find that quantity proceed as follows:

S - latitude	42°	19'	56"	Log sin	9.82829
S - altitude	64	51	20	Log sin	9.95676
S - Polar Distance	25	57	35	Colog Cos ..	0.04619
S	81	13	42	Colog Cos ..	0.81674
Log $\cot^2$ 1/2 azimuth					0.64798
divide log by 2 to get square root.					
Log cot 1/2 azimuth					0.32399
(the cologs of cosines are the log cosines subtracted from 10)					

Angle corresponding to log cot 0.32399	25°	22'	22"	= 1/2 azimuth
Azimuth of the sun	50	44	44	
Angle between rod and sun	+91	19	33	
Azimuth at station 624 to station 625	319	25	11	= S. 40° 34' 49" E.

If the angle between the rod and the sun is plus, subtract it from the azimuth of the sun; if minus, add it.

An example of field notes for morning observations is given below:

Instrument, station 426; rod, station 427.
Latitude, 42° 36' 24".
Date, August 14, 1925, 75th meridian time.

	Vernier Readings						Vertical Angles to Sun			
Rod	0°	00'	00"	180°	00'	00"				
Sun	312	40	00	132	40	00	38°	55'	00"	Time of first pointing at sun $8^h\ 40^m$ A.M.
Sun	312	50	30	132	50	30	39	04	00	
Sun	312	58	30	132	58	30	39	11	00	
Sun	313	07	00	133	07	00	39	17	30	
Sun	313	14	00	133	14	00	39	22	30	
Rod	0	00	00	180	00	00				
	Reverse Telescope									
Rod	0°	00'	00"	180°	00'	00"				
Sun	313	39	00	133	39	00	39°	40'	30"	
Sun	313	48	30	133	48	30	39	49	30	
Sun	313	58	00	133	58	00	39	57	00	
Sun	314	08	30	134	08	30	40	03	00	
Sun	314	16	00	134	16	00	40	10	00	Time of last pointing at sun $8^h\ 44^m$ A.M.
Rod	00	00	00	180	00	00				
	3134	40	00				395	30	00	17 24

Mean of readings 313° 28' 00". Mean time of observation ..... $8^h\ 42^m$

Subtracting mean from 260 gives mean angle, rod to sun, 46° 32' 00" east of south.

Mean of vertical angles	39°	33'	00"
Correction for Refraction		01	10
Correct altitude of sun	39	31	50

The azimuth is computed from the field notes according to the formula given on page I-31.

Observations for August 14, 1925, $8^h\ 42^m$ A.M., seventy-fifth meridian time. When it is noon at Greenwich it is 7 A.M. on the seventy-fifth meridian (75 ÷ 15 = 5; 12 noon - 5 hours = 7 A.M.). The mean of the times of observation is $8^h\ 42^m$ A.M., 1 hour and 42 minutes (=1.7 hours) after 7 A.M. local time or Greenwich noon. In the tables showing the position of the sun for the year 1925 the sun's apparent declination at Greenwich noon on August 14 is given as 14° 27' 08" north. The declina-

tion is decreasing at the rate of 46.12 seconds per each hour after Greenwich noon. The observation was made 1.7 hours after Greenwich noon, therefore the change in the declination of the sun since the preceding Greenwich noon is 46.12x1.7 = 74 seconds = 1 minute and 14 seconds.

Declination (north) August 14, 1925 at Greenwich noon	14° 27' 08"
Correction to be subtracted for 1.7 hours	1 14
Declination at 8^h 42^m A.M.	14 25 54

Subtracting the declination from 90° gives the polar distance:

	90° 00' 00"
Declination	14 25 54
Polar Distance, August 14, 1925 8^h 42^m A.M.	75 34 06

To find the value of S:

Latitude	42° 36' 24"	
Altitude of Sun	39 31 50	
Polar Distance	75 34 06	
	157 42 20	
1/2 of Sun	78 51 10	= S
S	78° 51' 10"	
Latitude	42 36 24	
	36 14 46	= S-latitude
S	78° 51' 10"	
Altitude	39 31 50	
	39 19 20	= S-Altitude
S	78° 51' 10"	
Polar Distance	75 34 06	
	3 17 04	= S-polar distance

To find the azimuth angle of the sun from the data given proceed as follows:

S-latitude	= 36° 14' 46"	Log Sin	9.77177
S-altitude	= 39 19 20	Log sin	9.80187
S-polar distance	= 3 17 04	colog cos	0.00071
S	78 51 10	colog cos	0.71370
Log $\cot^2$ 1/2 azimuth			0.28805
Log cot 1/2 azimuth			0.14402

Angle corresponding to log cot 0.14402 35° 40' 10"

1/2 azimuth.

Bearing of sun, 71° 20' 20" (east of south)

	360°	00'	00"	
	- 71	20	20	
Geographic Azimuth of Sun	288	39	40	
Observed angle between rod and sun	+ 46	32	00	
Azimuth at station 426 to station 427	335	11	40	S. 24° 48' 20" E.

Geographic azimuths are counted clockwise from the south (0° or 360°; west, 90°; north, 180°; east, 270°).

In case unfavorable weather prevents the taking of azimuth observations leave adequate marks at a point selected, before proceed with the line, and return later to make observations.

Watch error. - The instrument man must carry a reliable watch and keep it in good condition. He should ascertain its error daily by comparison with telegraphic time, which is sent over Western Union lines once a day. In case he has no opportunity to make this comparison daily while running the line, he should do so as often as possible, figure the rate of error per day, and record the proper correction for each azimuth observation made. A watch error of 20 seconds or less will not appreciably affect the accuracy of the determination.

Magnetic Declination. - A careful reading of the needle for magnetic declination should be made at frequent intervals and recorded opposite the proper station number in the notebook. Such determinations should be made at each azimuth station and at favorable points along the line where the needle is not

likely to be affected by rails, electric wires, or similar disturbing elements. At azimuth stations determine the magnetic bearing of the azimuth mark at the time it is established. If the line follows a railroad, magnetic determinations should be obtained from a parallel line at a distance of 25 yards from the rails or wires.

Field record. Complete field notes must be kept by the recorder in book 9-928, to be written in a plain, neat hand with a #4 pencil. The blanks in the title page should be filled in the first day the book is used.

The recorder must take down the vernier readings as they are called off by the transit man and compute the mean pointings and deflection angles, giving proper signs to the angles. He must keep up with the instrument man in these computations, as they enable him to note by inspection whether the instrument man has made errors in his readings and call attention to them before the instrument is removed from the station. He should take special pains to see that the degree and minute numbers for the two verniers are consistent and are recorded in the proper columns. A single line should be drawn through erroneous records, which must never be erased.

The notes are kept in the following form:

Date, September 9, 1925. Line from Pikeville to Dayton, Mo.

Station No.	Distance (ft.)	Vernier A	Vernier B	Mean	Deflection Angle	Azimuth	Stadia
		° ' "	° ' "	° ' "	° ' "	° ' "	
		316 51 30	136 52 30	316 52 00	--- -- --	[a] 123 35 00	-------
326		275 06 30	95 07 00	275 06 45	41 45 15	---------	-------
		233 21 00	53 22 00	233 21 30	41 4 15	[b] 81 49 45	Stadia
							905
	900	---------	---------	---------	-41 45 15	[a] 81 49 47	-------
		[c] 233 21 00	53 22 00	233 21 30	---------	---------	Sta. 327-328 N. 59° 30' W.
327		279 04 30	99 05 00	279 04 45	45 43 15	---------	-------
		324 48 30	144 49 30	324 49 00	45 44 15	[b] 127 33 30	Sta. 1330
	1320	---------	---------	---------	+45 43 45	[a] 127 33 34	-------
327+	90	Stream crossing.					
327+	430	Crossroad at Tanbark.					
		[c] 324 48 30	144 49 30	324 49 00	---------	---------	-------
328		342 08 00	162 09 00	342 08 30	17 19 30	---------	-------
		359 27 00	179 28 00	359 27 30	17 19 00	[b] 144 52 45	St. 260
	260	---------	---------	---------	+17 19 15	[a] 144 52 43	-------

a - Written in red ink.
b - Written with black pencil.
c - From actual readings; not copied from the preceding record.

The record must contain also a description of the starting and ending points of the line, of each permanent mark established along the line, of each point which is to be computed for the use of the topographer, and of all crossings and other landmarks that may be of value to him. Such descriptions should be concise yet full enough to leave no possible doubt as to the identity of the points described. Each should be supplemented by an explanatory sketch, if necessary, showing the deflection angles to the reference marks, as the true azimuths to these marks are required. The description should begin on the next line after the angle record.

Example of description of permanent mark:

Station 1025, bench-mark tablet stamped "Trav. Sta. #4, 1912" set in sandstone ledge, top of Walden Ridge, 3 miles northwest of

Dayton, Mo., at junction of Dayton, Pikeville, and Morgan Springs roads, 325 feet west of residence of John Neilson. Reference marks: Cross cut in ledge 60.25 feet N. 25° 30' E.; spike in root of white-oak tree 14 inches in diameter 75.60 feet N. 45° 15' W.

Examples of description of points to be computed and other landmarks:

Station 625 + 730 feet, center of crossroads at Antioch Church.
Station 720 + 320 feet, east abutment of bridge over Glade Creek.
Station 732, road fork at Johnson blacksmith shop.
Station 926 + 210 feet, center of track opposite semaphore, Lee station.
Station 936 + 300 feet, road crossing half a mile east of Sequatchie railroad bridge.

Each point to be computed should be marked with brackets in ink immediately upon its selection by the instrument man.

As soon as the records in a field book are completed, it should, if not needed for reference, be sent at once to the Survey office in Washington by registered mail. Tapeman's books should be sent separate from other notes and on another day.

TRUNK-LINE TRAVERSES

The foregoing instructions apply also to trunk-line traverses, for which an accuracy of 1 in 7,500 is required. The only difference in methods between the two grades of work is that much greater care will be required for each operation, in both the field and the office, for the trunk lines. Temperature corrections must be made, and computations carried to tenths of a foot.

TRANSIT-TRAVERSE COMPUTATIONS.

The steps in traverse computations are set forth below. The computations are made in books 9-928 and 9-931. The abstracts of results are placed on long sheets of papers. Each azimuth computation is to be made in the field notebook on the same page with the observations, and the results written in red ink in the azimuth column of notebook (see pp. 101, 111) on the line with the station occupied.

Computers should read carefully the "Suggestions to computers" on pages 86-87.

Field computation of azimuth. - Azimuth notes must be computed as soon as possible after observations are made and the results applied to the deflection angles. These computations must be made at odd times, when they will not interfere with other work. Errors of closure in azimuth should not be distributed until checked by a second computer either in the field or in the office. Allowance must always be made for convergence of meridians.

Computation of Deflection Angles. - The mean deflection angle is combined according to its sign with the azimuth from the preceding station, and the result placed in pencil opposite the deflection angle used. This process is repeated until the next computed azimuth written in red ink is reached.

The last azimuth in pencil will probably not agree with the observed azimuth. For any line not running due north or south there will be a discrepancy between observed and computed azimuths, due solely to convergency of meridians, which

for latitude 30° will be 0.5 minute for each mile run east or west. For latitude 49° the amount will be 1 minute. For any latitude the convergence in minutes of arc will be the difference in minutes of longitude between the ends of the line multiplied by the sine of the middle latitude. For lines running east the computed azimuth should be less than the observed. For lines running west it should be greater.

Adjustment of Closing Error: If no large errors appear in the results, the discrepancy between computed and observed azimuths at the closing station is to be divided by the number of stations and a proportional correction applied to each penciled azimuth, the corrected figures being written in red ink. When a large closing error is found in a transit-traverse line look first for a compensating error of 1° or 10° in the azimuths or angles.

Computations of latitudes and departures. - Latitudes and departures are to be computed in book 9-931, as shown below:

LINE FROM PIKEVILLE TO DAYTON, MO.

Station	Azimuth	Distance	Sine	Co-Sine	N.	S.	E.	W.
	° ' "	ft.			ft.	ft.	ft.	ft.
326 to 327	81 49 47	900	0.990	0.142	----	128	----	891
327-430 feet	127 33 34	430	.793	.610	262	---	----	341
					262			1232
					128			
					134			
327-430 ft. to 328	127 33 34	690	.793	.610	543			706

Natural sines and cosines for the azimuths given are written in the appropriate columns. By means of Crell's tables the products of these quantities by distances are found

and placed in the proper columns. The sines multipled by the distance give departures east or west. When the sine is positive, the new point is west; when negative it is east. Cosines multipled by distances give latitudes north or south. When the cosine is negative, the new point is north; when positive it is south. The direction of the new point can readily be determined by noting the azimuth, remembering that 0° azimuth is for a line running due south, 90° for a line due west, 180° for a line north, and 270° for a line east. In the example given in the above table the azimuth 81° 49' 47", being between due south and due west, will be to a point southwest. Four decimal places in sines and cosines should be used when distances are greater than 1,000 feet.

When the Gurden traverse tables for distances 1 to 100 for single minutes of arc are available, the latitudes and departures may be written in the north, south, east, and west columns direct for each azimuth and distance.

Whenever a point is reached for which the latitude and longitude are desired, as at 327+430 feet in the example, leave six blank spaces for the computation. The data for the computation for such a point are found from the record on page I-38 as follows: For the crossroad at Tanbark post office, which is on the line between stations 327 and 328, the azimuth is the same as to station 328. The distance by measurement is that given, 430 feet from station 327. In order to make the computations continuous, station 328 is taken as 1,320 - 430 890 feet from the intermediate point used, the azimuth being the

same for both points.

Computation of latitude and longitude. - The next step in this work is the computation of latitude and longitude. These should be determined for important points a mile or less apart. Assume, for illustration, that for station 326 (p. I-38) the coordinates have been completed, and that 327 + 430 feet is the next location desired. Each of the four columns - north, south, east, and west - is summed; the difference between the sums of the north and south columns is placed in the column of the greater, and the difference between the east and west columns is placed in the column of the greater. The computations of latitude and longitude and the descriptions of the points are placed on the right hand page of the book opposite the group of stations.

The logarithms of the geodetic constants for metric measures, called "The A, B. C factors," are on pages 219-290 of "Geographic Tables and Formulas" (U. S. Geological Survey Bulletin, 650). Factors A and B are used to give decimal places only. These will be practically constant for a distance of 10 or 15 miles north and south, the value for the middle latitude being used.

For the example on page I-41:

Log Distance 134 (north)	2.12710
Log to reduce feet to meters	9.48402
Log B for latitude 39° 00'	8.51093
	0.12205

The sum, 0.12205, is the logarithm of change in latitude in seconds between station 326 and 327 + 430 ft. 1.32" (north).

For change in longitude:

Log. distance 1,232 (west)	3.09061
Log. to reduce feet to meters	9.48402
Log A for latitude 39° 00' 00"	8.50914
Log secant of middle latitude	0.10950
Log of change in longitude in seconds ..	1.19327
New point west	15.61"

These differences are to be added to the latitude and longitude of station 326.

When the survey tables of M and P factors, prepared by D. H. Baldwin, are available the computation of changes in latitude and longitude may be materially shortened by adding log M to the log of distance north or south for change in latitude and by adding log P to the corresponding distance east and west for the change of longitude.

The foregoing computation would then be written as follows:

For the latitude change:

Log distance 134 (north)	2.12710
Log M for latitude 39° 00'	7.99495
Log of change in latitude in seconds ...	0.12204

(The difference in the fifth place is the result of carrying forward decimals from the sixth place in the first computation.)

For the longitude change:

Log distance 1,232 (west)	3.09061
Log P for middle latitude	8.10266
Log of change in longitude in seconds ..	1.19327

To check the plotting of positions on topographer's field sheets the distance between successive positions must be computed. As few lines are as much as one mile in length and none over 2 miles, the latitude and departure can with

sufficient accuracy be taken as the base and perpendicular of a plane triangle. The distance sought will be the hypothenuse, and its square will be equal to the sum of the squares of the base and altitude. For distances less than 10,000 feet Barlow's tables should be used in finding squares or square roots. The distance should be written in red ink, enclosed in a circle, on the right-hand page of the computation book in the blank space between the entries for the two stations referred to. After the record is complete its accuracy may be tested by computing a side from the given distance (hypothenuse) and the other side.

Adjustment of closures. - These operations are repeated for each selected point until the traverse line closes back on itself or ties to another point previously determined. The erros of closure for a 15 minute quadrangle, if not in excess of 1 second in latitude or 1¼ seconds in longitude, may be distributed proportionately between initial and closing points, provided the error is not greater than 1 in 5,000 parts of the distance between them for ordinary lines or 1 in 7,500 for trunk lines.

Errors: Where so many operations are involved, errors are likely to creep into the computations. Therefore, each step of the work should be checked as well as possible. The azimuth computation may be compared with the observed magnetic bearings, but because of the possibility of local variation little dependence can be placed on this comparison as a check. If the computed and observed azimuths for a line differ about

10 minutes, look for an error of that amount in the deflection angle or in the adding and subtracting of deflection angles to azimuths. If the difference is larger, it is very likely that a wrong sign has been used for a deflection angle. To find the error, divide the difference by 2 and look for a deflection angle with an incorrect sign equal to the quotient. Errors of about 180° result if the recorder places the vernier readings in the wrong columns. By a careful inspection of the records it is sometimes possible to detect such an error. Many errors are due to incorrect multiplication by the distance, to the decimal point being in the wrong place or to the product being written in the wrong column, etc. The latitudes and departures, as well as the other steps in the work, should be computed by two persons working independently of each other; after each has completed each step of the work the results should be compared and differences corrected and verified.

A plat must be made by the computer on an approximate scale of 5 miles to 1 inch, on one or more pages of book 9-931 for each group of traverse notes. In the center of the plat of each circuit write the length of the circuit and the closing error.

Plane Table Triangulation

This type of triangulation is highly efficient and economical and should be used throughout this Region wherever possible. The engineer should bear in mind that plane table triangulation is a break-down net from first, second, or third order control. Since the accuracy of this break-down net will not be as great as that of first, second, or third order control, it will be within the plotting limits of the scale on which the planimetric map is to be compiled.

Field Party: The party for plane table triangulation should consist of an instrument man, being chief-of-party, and one assistant or helper. In most cases two assistants will not be found of value because they will only lead to confusion and more expense for the party as a whole. In some cases however, such as on pack trips, an extra man may be found useful in making and breaking camp. In this case, the chief-of-party should use his judgment as to the number of helpers necessary. Care should be taken in selecting a helper for this type of work as the hours and working conditions are considerably different from what the average young man is accustomed to and consequently if he becomes dissatisfied easily he may not remain long with the job.

Equipment: The party will be equipped with a suitable automobile, preferably of the panel body type, with sufficient gas capacity to enable long trips between filling stations. The following equipment will be furnished:

1 - 18-Power Alidade with 18" Blade
1 - 30x36" Plane Table Board
1 - Tripod with Johnson Head
1 - 14 Foot Stadia Rod
1 - 100' Steel Tape
2 - Hand Axes
2 - Double Bit Axes
1 - Hand Saw
2 - Chisels
1 - Heavy Machine Hammer
1 - Pair Binoculars
1 - Crow Bar
1 - Set of Number Dies
1 - Set of Letter Dies
1 - Geodetic Scale
1 - Flat Boxwood Scale
1 - Set of Drafting Tools
1 - Stereoscope - Portable Type
Supply of Wire
Nails
Flagging

The party should carry only that equipment which is essential. Too much equipment is only in the way and tends to make travel slow, as well as adding to the chance of loss and breakage.

Supplies: The chief-of-party will be furnished with sufficient plane table sheets mounted on metal to cover the entire project, all necessary stationery with stationery cabinet or field chest, a set of stereoscopic photographs covering the entire area, and a set of the best existing maps.

Approach to Work: Before entering upon a Forest, the chief-of-party should introduce himself to the Supervisor and all of the rangers on whose districts he expects to work. He should explain briefly the type and purpose of his work. In this manner the personnel of the Forest will understand his needs and will be able to assist him greatly in locating found section corners, trails, roads, etc.

In cases where the work extends upon private property, the chief-of-party should always get permission from the owner of the property (or some one authorized to give this permission) before entering upon their land. In some cases it is not only unwise but unsafe as well to enter upon private ground without first gaining permission even though the land may not be fenced or posted.

The chief-of-party will find that he will seldom be excluded from private property after he has made his purpose clear to the owner. On the other hand, if he does not do this his flags will usually be torn down since the reason for their presence is not known.

Care of Alidade: Too much emphasis can not be placed on the care in handling and transportation of instruments. Every employee entrusted with instruments in the field is expected to keep them clean and in adjustment, to protect them from undue wear, and to return them to the Engineering Equipment Custodian in condition for immediate use.

Every party chief should provide himself with a few simple tools such as a small pair of pliers, a small screw driver, brass nails, oil, and whatever else he thinks is necessary to make minor repairs on his equipment. Field work should never be delayed by sending an instrument away for small repairs. Crude repairs may often be made to serve while another instrument is being procured.

Adjustment of Alidade: The object glasses and eye piece must be properly focused. The cross wires, projected

against some distant object should appear immovable when the eye only is moved. Before adjusting, the plane table must be firmly set up and carefully leveled. Before attempting to adjust an instrument it must be made certain that the apparent trouble is not due to some loose part or parts, such as screws, object glass, eye-piece, etc. When adjusting, all screws should be tight enough to hold but care should be taken not to injure the threads or put a strain on any one part. Special care should be taken not to strain the cross hair screws.

Collimation: With the alidade resting on a level surface, sight the vertical wire on some nearby object, then by raising and lowering the telescope observe whether the cross wire remains on this object. If the wire is found to be out of its true vertical position, loosen the screws on the cross wire ring and by a slight shift in the position of the ring, bring the vertical wire into its true vertical position. For triangulation, the ring screw on the telescope tube should be tightened and the telescope never revolved about its axes. It is sometimes advisable to have a small set screw to hold the telescope in a locked position in case the ring screw does not hold tight enough.

Circular Level: Place the alidade on a level surface and bring the bubble to the center of the glass by means of the adjusting screws.

Ruler: So long as but a single edge of the ruler is used it makes no difference in the results whether or not the ruler and the line of sight are parallel.

Flagging Stations: When starting the process of flagging a quadrangle, it will usually be found helpful to flag all existing first, second, and third order triangulation stations first, using large quadrapods carrying a flagpole and 4 legs which form the frame for a skirt near the top. (See Page I-53.) This skirt increases the distance from which the flag may be seen about double that of a single pole and flag.

After existing stations have been flagged, plane table or breakdown stations may then be flagged.

For good control these break-down stations should be spaced three to five miles apart, and in no case over seven miles apart. Since these stations are so close together, it is not always possible to set them on high points. However, high prominent points should always be used if they are available. These stations can be flagged either with a flagpole nailed to the top of a tree, or if in barren country a quadrapod with flagpole and skirt or rock cairn. (See Page I-53.)

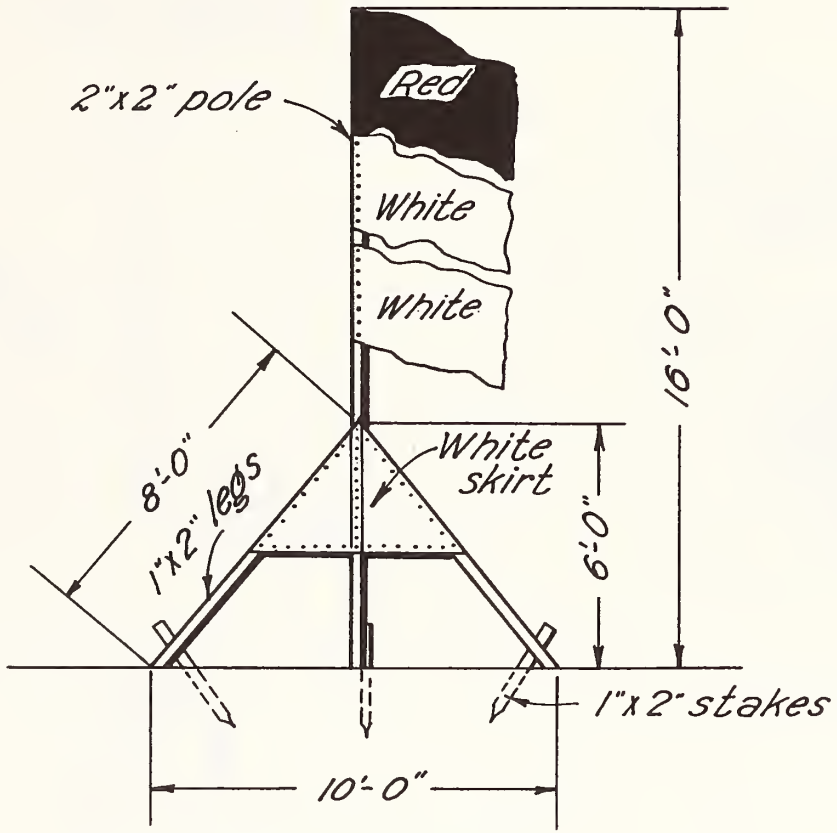
Care should be taken when flagpoles are nailed to tree tops since they are the most likely to be blown down. The main stem of the tree should be cleared of all limbs for about six feet below the top (see Page I-53). The top tuft of the tree should then be cut off. The flagpole should

overlap the tree stem for about three feet and nailed to it with two or three nails long enough to allow them to be clinched. Then wire with 14-gauge soft iron wire and twist tightly.

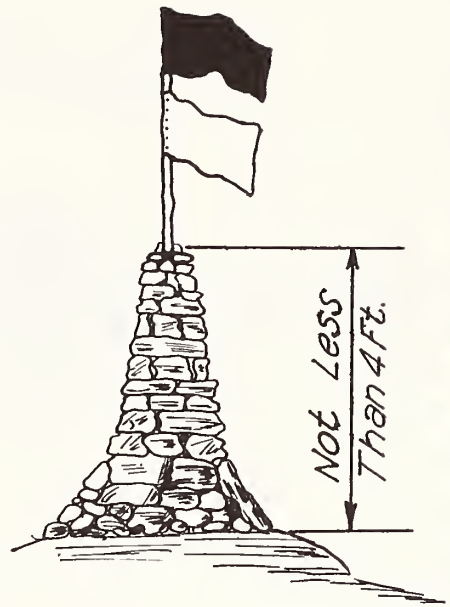
In case a quadrapod with skirt is used, the skirt should be slit with a knife at several places to let the wind through. In some localities, around picnic areas for instance, where there is danger of the flag being removed and used for other purposes, it is wise to slit all the flags. This slitting renders them useless for dish rags but still leaves them visible for triangulation.

The chief-of-party, of course, must use his judgment as to the selection of flagging, depending in all cases upon the distance from which the station is to be viewed. For instance, a flag which will show up against the sky from the point of vision, red flag should predominate over the white. In open, untimbered country a tree about ten feet high can be transplanted and placed by wiring to stakes. This usually makes a station which can be seen much better than one with either red or white flags.

In high, barren country where flagpoles are scarce, it is usually better to take time to erect a cairn. A cairn six feet high can be seen as far as twenty miles, and will not be blown down. If a cairn is set, all other cairns in the vicinity should be torn down to avoid confusion in picking the right one when sighting back. For reference see



QUADRAPOD SIGNAL

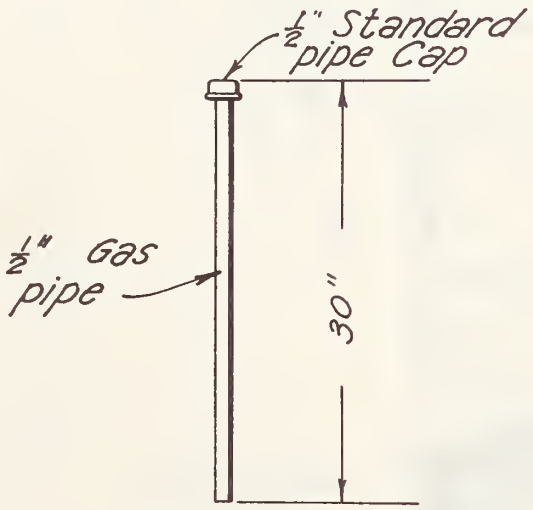


CAIRN & FLAG SIGNAL

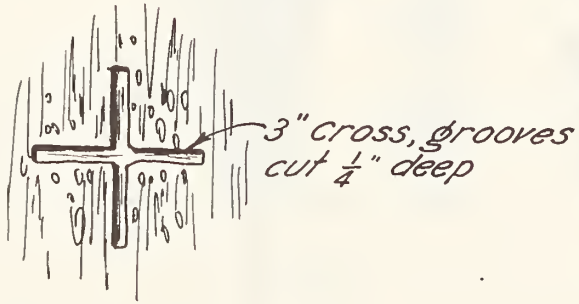
TREE SIGNAL

FIG.

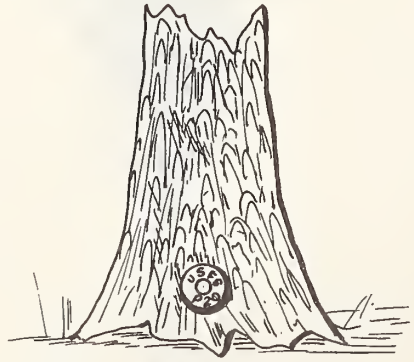
TOP OF CAP



PIPE MARKER
For open untimbered country



ROCK MARKER
For rocky, barren and untimbered country



TREE MARKER
For timbered country

FIG.

Page I-91 for curvature and refraction correction in feet and miles.

Station Marking: All stations shall be marked as shown on Page I-54.

The left-hand sketch shows the standard pipe and cap marking used for open, untimbered country. This pipe is driven into the ground to such a depth that it will not extend above the ground more than six inches. The cap shall be stamped with the letters "U S F S" and the number of the station, such as P-127, etc.

The right-hand drawing shows the typical marking for stations where the flags are placed in trees. A cut washer $1\frac{1}{2}$" in diameter or larger may be used. It is marked in the same manner as the cap on the pipe, and nailed to the base of the tree about eight inches above the ground. Care should be taken to keep this marker low on the tree. In the event the treet is cut, the marker will not be destroyed.

The center drawing on Page I-54 shows the type of marking used on peaks or rock knobs where no trees are available. A cross about three inches long and 1/4" deep is cut in the rock. This may be done with a chisel or some other cutting tool. Care should be taken to place this marker on the highest point of the mountain to avoid the necessity of future parties having to make a search for its recovery.

The numbering system for stations should be as follows: Each chief-of-party should start with the number "one" and continue in numerical order as long as he does this type of work

for the Forest Service. For example, if his last number on a sheet is 200 when he quits work for the winter, his next number in the spring will be 201. In this manner he will never have a number repeated which, of course, would cause confliction in the office files.

Each number should be preceded by the initial of the surname of the chief-of-party. This letter will always give a clue as to the person setting the station and also avoid confusion if two parties are working close together.

Cutting in Stations: As soon as a full quadrangle is flagged and marked the chief-of-party should then start cutting in and locating the stations he has set. This is done by first occupying the previously established U. S. Geological Survey and U. S. Coast and Geodetic Survey triangulation stations. Time will be saved by cataloging each of these stations and entering below the name of the station, the number of the plane table stations which can be seen from it. This catalog should be made as the plane table stations are being set. This list can then be used as a check list when the latter stations are cut in. This makes it almost impossible to omit a station. When the first station is occupied, a permanent north arrow should be drawn on the plane table sheet for use in rapidly orienting the plane table board on the following stations.

When using a scale of one inch = 1 mile, it is not necessary to set the plane table directly over the station mark. However, in no case, should the table be set eccentric

to the station signal by more than 10 feet. When working at a scale of 2" = 1 mile, the table should be set directly over point of the station occupied and in case this can not be done, the eccentric distance from the signal must be measured and plotted on the sheet. The lines from this station will then radiate from the newly plotted position.

Utmost care should be used in leveling and orienting the table. The most distant, pre-established station should be used for orientation, and lines drawn to new stations should always be extended the full length of the blade. The approximate location along this line should be estimated and a light circle drawn around it. This sometimes saves confusion in crossing the right lines when the station is sighted from other point.

After all U. S. Geological Survey and U. S. Coast and Geodetic Survey triangulation stations have been occupied, the strongest plane table stations should be occupied in the order of their strength. In no case shall a station have less than three cuts to it, nor shall it be over two stations removed from third order triangulation. Sufficient stations should always be set along the sheet edges to insure ties to the adjacent quadrangles, and the points should not be over five miles apart and common to both sheets. In other words, they will be within one inch of the outside minute lines of the sheets. The stations near the corners of these sheets should be close enough to each corner so that they may be plotted on the three adjacent sheets, since this is the weakest point on

the sheet and consequently needs the most checking.

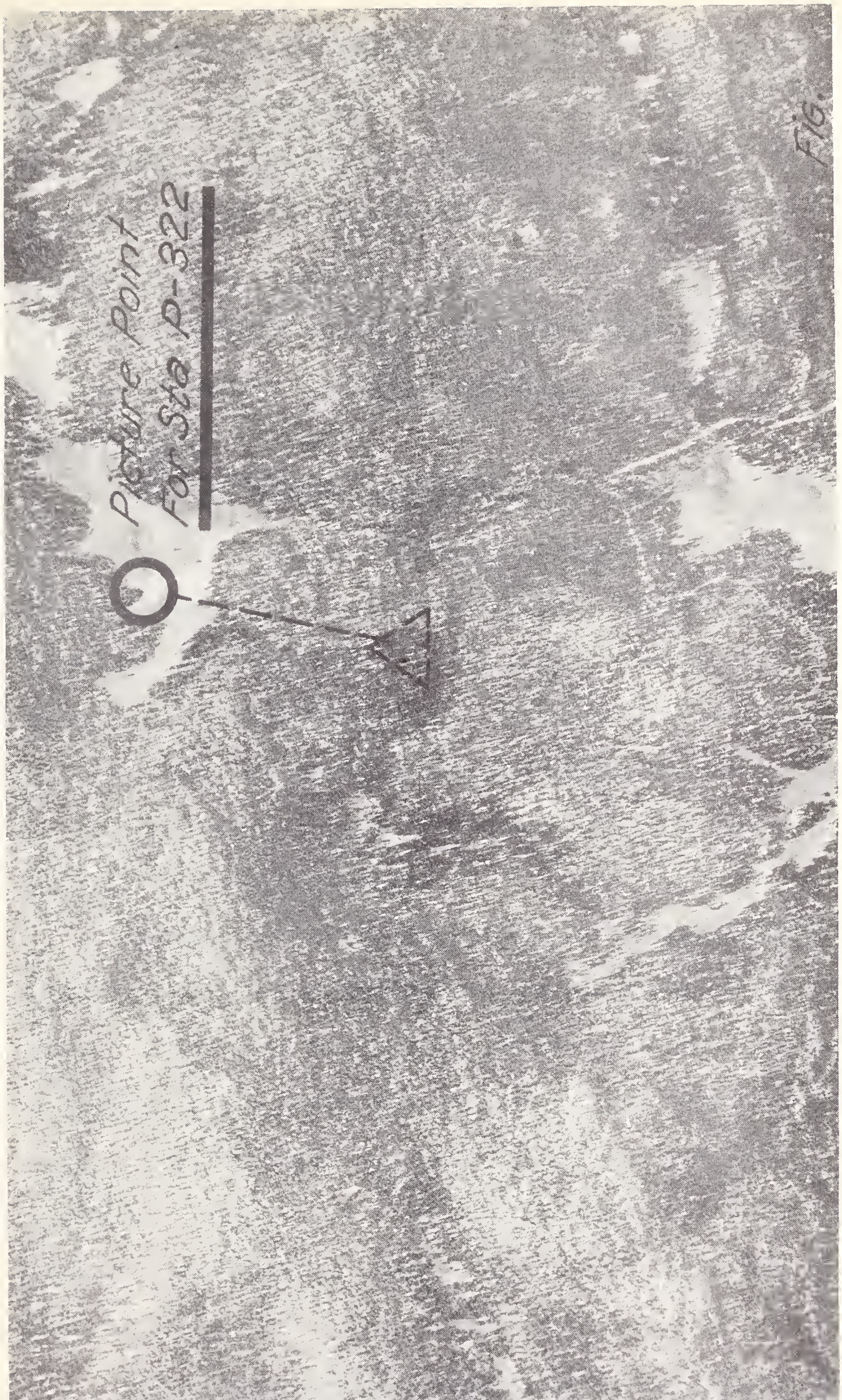
If two sheets fail to close with respect to each other by more than one second of latitude or longitude, an error should be looked for and the sheets closed within this limit. In case a scale larger than 1" = 1 mile is used sheets should close to .01" with respect to each other.

At the same time stations are cut in, all available section corners should be cut in and plotted. At least one section corner per township should be found and plotted. These corners should preferably be at township corners, or along township or range lines as these are the most likely to be correct. These corners are very essential to the compilation of the final map. When it is impossible to identify these corners on the photographs, it is much better to show their latitude and longitude on the plane table sheet and leave the point unidentified on the photograph. Doubtful identification should be avoided altogether.

Identification of Control: Every triangulation station should be identified on the photograph by marking with a pin hole and circling with black ink, and numbering on both front and back sides with black ink. In case a station can not be identified positively, an eccentric station should be established on some definite mark on the photograph. The method for doing this is shown on Pages I-59, I-60, and I-61. Page I-59 shows a mountain, the top of which lacks definite marks and is too rounding to pick the definite top at which the signal was set. In this case a tree or some other prominent


Fig.
750 Ft.
Picture Point
For Sta P-320


750 Ft.
Picture Point
For Sta P321
FIG.


Picture Point
For Sta D-322
FIG.

object such as a large boulder, clump of brush, etc., may be used as a picture point. The instrument is set up over the station and oriented, a distance is then shot to the picture point and its true position with reference to the original station is plotted. Then the tree itself is needle-pointed and labeled - Picture Point for Station F-320, or whatever it may be. No attempt is made to identify the station itself.

Page I-60 shows a station which is located in open sagebrush country where no definite objects can be located at the station. In a case of this kind, a distance is also taken to some definite object. It can be a house, road, intersection, field corner, etc. This object is picked on the photograph and marked in the same manner as referred to in the preceding paragraph. No attempt should be made to identify the original station.

In some cases where the terrain is heavily timbered, (see Page I-61) and salient points are not easily found, the station may be used by setting a picture point on a lone tree or cutting in the timber such as a fire line. Page I-61 shows where a point of timber has been used as a picture point. It may be necessary to make a plane table traverse to reach this point from the original station, but in any case it must be made, otherwise the station is useless as a control point.

All stations should be identified in the field at the time they are set. It has been found very unsatisfactory to attempt to identify control points in the office. One station

mis-identified on a quadrangle throws doubt on the remaining stations, regardless of the fact that they may be perfect for location and identification.

Inking Sheets: After all stations on the plane table sheet have been cut in the sheet is ready to be inked with black waterproof ink. All lines of visibility should be lightly inked between stations and a circle about 1/10" in diameter drawn around each station. The station number and the photograph number upon which it is identified should be lettered above the station. This operation should be done in the field when the sheet is finished. The latitude and longitude for the station should be scaled off to the nearest 1/4 second and lettered below the station. This latter operation, however, may be done at some later date.

Description of Stations and Bearings: Every station which bears a number should be described with reference to the nearest town, giving mileages, directions, relation to land marks, etc. It must be so described that a person who has never seen the locality will bd able to find the station with the least possible difficulty. This description must be made in the field before leaving station, and in no case should the chief-of-party rely on his memory to make the description at a later date. The description blanks provided for this purpose (See Page I-65) also have spaces for the date, latitude, and longitude, class of work, etc., which should all be filled in. At the lower part of the blanks, a space is provided for showing the distances and true bearings to all other visible

JOB _____ DATE _____

STATION _____

U.S.G.S. QUAD: _____

_____ COUNTY

Accuracy _____

_____ Datum

Photo _____

Latitude _____ Longitude _____

Description

Signal:

Station Mark:

To Station	Distance in Miles	True Compass Bearing

stations. This space may be filled in at some later date. This information is obtained by scaling the distances between the stations and measuring the angles from north or south by means of a protractor. The blanks should be assembled in numerical order and turned over to Surveys & Maps for typing in book form.

Towers: Towers may be of several different types. In oak brush country where cover is not over ten or twelve feet high, small portable towers may be used, and moved from one point to another by simply dismantling. These towers should be constructed in such a way that the plane table or instrument is supported from a tripod coming through the center of the platform and is entirely disconnected from the platform and tower supporting the weight of the instrument man. The legs of the plane table tripod may be strapped to the inside of the tower tripod legs at the top and the tower tripod itself made rigid by means of guy wires.

When coverage is much taller this same tower may be constructed higher to obtain visibility and guard rails should be constructed around the platform for the safety of the instrument man.

In some cases where timber is very close together a tower may be constructed from a group of trees by first cutting out the top and pulling the outside trees together to form the frame for the platform and using a center tree for the instrument stand.

Experience is the best teacher in the construction of improvised towers since every one will be different and require a different method of approach.

Pack Trips: In isolated mountain country where roads are scarce it will always be found advisable to use pack horses. Full pack equipment can usually be secured from the party renting out the horses. For a trip of two weeks or more it is best to use four horses - one for each of two men, and two pack horses for supplies. The alidade should always be carried in a pannier, in its packing box. The packing box should be filled with crumpled newspaper so that the instrument will not be jarred in any way. The plane table board may be carried flat on top of one pack outfit while the tripod may be carried on the other. Always make sure that the paper sheet of the board faces upward - otherwise, the pack saddles will wear holes through the paper within a few miles. The legs of the tripod should be packed so that the points of the legs are pointed to the rear. This is a safety measure and prevents injury in case the horse falls. Only essential cooking equipment should be carried since it is bulky and hard to pack. Food may be selected from the Forest Service ration lists.

If the party is making a pack trip for the first time is is wise to take along an experienced packer. There are a good many tricks in packing which can be more easily learned from watching someone experienced than by trial and error.

Summary: Regardless of type of control follow all rules rigidly.

No line should be shot which is longer than the base of orientation. Neither should a line be resected from a station if the line is longer than the base of orientation.

Photo identification of stations should be done in the field at the station. This identification should be very carefully checked. Sometimes two different sections of the country several miles removed from each other will appear almost identical on the photographs. Chances of misidentifying points in these sections may be eliminated if the photographs are laid out in mosaic form and distances between control stations checked with reference to these same distances and angles on the plane table board. Then if a point is misidentified by any great amount, it will immediately be discovered.

Never three-point station locations. This is a process for an expert and even he will make mistakes by using this method.

If an error appears in the work, do not hesitate to erase a station and start over.

CONSTRUCTION OF PROJECTIONS (As given by U. S. Geological Survey)

For making a polyconic projection by this method it is necessary to have a metal straightedge graduated in inches, with one inch at one end subdivided into hundredths of an inch, the scale being standardized, and the straightedge being as long as the longest dimensions of the projection; a good rigid-beam

compass with micrometer movement; a hard chisel-point pencil, a plotting needle, and the tables in this publication.

To illustrate this method the construction of a polyconic projection on a scale of 1:63,360 of the 30-minute quadrangle lying between north latitudes 39° 00' and 39° 30' and between west longitudes 105° 00' and 105° 30' is described on Page I-75 . The projection will show each 5 minute meridian and parallel. The central meridian of the projection will represent the meridian of longitude 105° 15' and will be used for construction only. Likewise, the perpendicular crossing the central meridian at latitude 39° 15' will be used for construction only. The geometry of the construction given is slightly different from previously ewtablished practice, owing principally to an effort to eliminate the plotting of the small ordinates of curvature, which is very difficult in a projection of a small quadrangle.

On Page I-75 the group of ordinates and meridianal distances computed for latitude 39° may safely be used for all latitudes between 38° 30' and 39° 30' without interpolation between the values given and those computed for latitudes 38° and 40°. The meridianal distance for 5' of latitude is found to be 5.748 inches; for 10', 11,497 inches; and for 15', 17.245 inches. In the part of the table headed "Abscissas of Developed Parallel" the X values for 5', 10', and 15' of longitude in latitude 39° are found to be 4.486 inches, 8.971 inches, and 13.457 inches respectively. The X values for latitude 39° 15' and 39° 30' are shown on Page

I-75. In the group of ordinates of developed parallel the Y value for 15' of longitude is found to be 0.018 inch, 10' of longitude to be 0.008 inch, and for 5' of longitude 0.002 inch. These are all the measurements needed to proceed with the construction of the projection. It is impossible to plot the Y value for 5' of longitude and difficlt to make an individual plotting of the Y value for 10' of longitude, but 0.018 can be added to or subtracted from any tabulated length of meridianal arcs and the resultant distance measured on the metal scale, and this is done in the following description:

Draw the central construction meridian AB in vertical position near the center of the map; select the mid-point C on the center of the projection, and lay off from C the meridianal distances for 5' 10' and 15' of latitude - CE (5.748 inches) CR (11.497 inches) and CB' (17.245 inches) above, and CD (5.748 inches) CS (11.497 inches) and CA' (17.245 inches) below. The over-all distance A'B' (34.491 inches) for 30' of latitude should be used to check the plotting. At the mid-point C erect the perpendicular FG, using the points A' and B' as centers for long arcs and the points D and E as centers for short arcs. Lay off on the construction line F G the abscissas of the developed parallel for 5', 10' and 15' of longitude for latitude 39° 15' - CH and CI (4.470 inches), CU and CX (8.940 inches) and CF and CG (13.409 inches).

With the points F' and G' as centers and a radius equal to the meridianal distance for 15' of latitude plus the ordinate for 15' of longitude (17.245+0.018 = 17.263 inches), strike arcs at J and K. Then with the same points as centers and a radius of 17.227 (17.245 -0.018) strike arcs at L and M. In striking these arcs use the metal point of the beam compass rather than the pencil point, and either scratch the paper lightly or place under the metal point a small piece of carbon paper made by rubbing a piece of thin tracing paper with a hard pencil. This obviates the inaccuracy of using the pencil point of the beam compass to take an exact measurement from the scale.

With the points H, I, U and X as centers and a radius equal to the meridional distance for 15' of latitude (17.245 inches), strike arcs at N, O, T, and W above and P, Q, V, and X below. The true meridianal distance as here used is generally taken in constructing the inner meridianal distance of 15' of latitude on a scale of 1:63,360 or larger, as it is impracticable to use the small ordinate for 5' of longitude. However, should the more rigid construction be required, it may be done in the following manner: with points H, I, U, and X as centers and a radius equal to the meridianal distance for 15' of latitude, plus the ordinate for 5' of longitude (17.245+0.002 = 17.247 inches), strike arcs at N, O, T, and W. Then with the same points as centers and a radius equal to the meridianal distance minus the

5' ordinate (17.245 -.002 = 17.243 inches), strike arcs to P, Q, V, and X.

With the points B' and A' as centers and radii equal to the proper abscissas strike arcs at J, K, L, and M, and at N, O, P, and Q and also at T, W, V, and X. Check the length of the diagonals JM and KL, which should be exactly the same. Draw the straight line JL and KM through the intersections of the arcs at J, L, K, and M and the straight line NP, OQ, TV, and WX through the intersections of the arcs at N, P. O, Q, T, V, W, and X. These lines represent the seven meridians on the projection, and although theoretically they are curves concave to the central meridian, yet in practice they can be drawn only as straight lines. The seven intersections at the top and the seven at the bottom of the projection are the exact intersections of the seven meridians with the limiting parallels.

With the beam compass set at the length of the meridianal distance for 5' of latitude, plot along all seven meridians down from J, T, N, O, W, and K and up from L, V, P, Q, X, and M, thus locating the intersections of the seven meridians with the parallels 39° 05', 39° 10', 39° 15', 39° 20', and 39° 25'.

All the necessary intersections for the projection of this 30' quadrangles have now been plotted without trying to make an individual plotting of 0.018 inches from the points F' and G', which only the most skilled draftsman can accomplish, and the same setting of the beam compass has been used

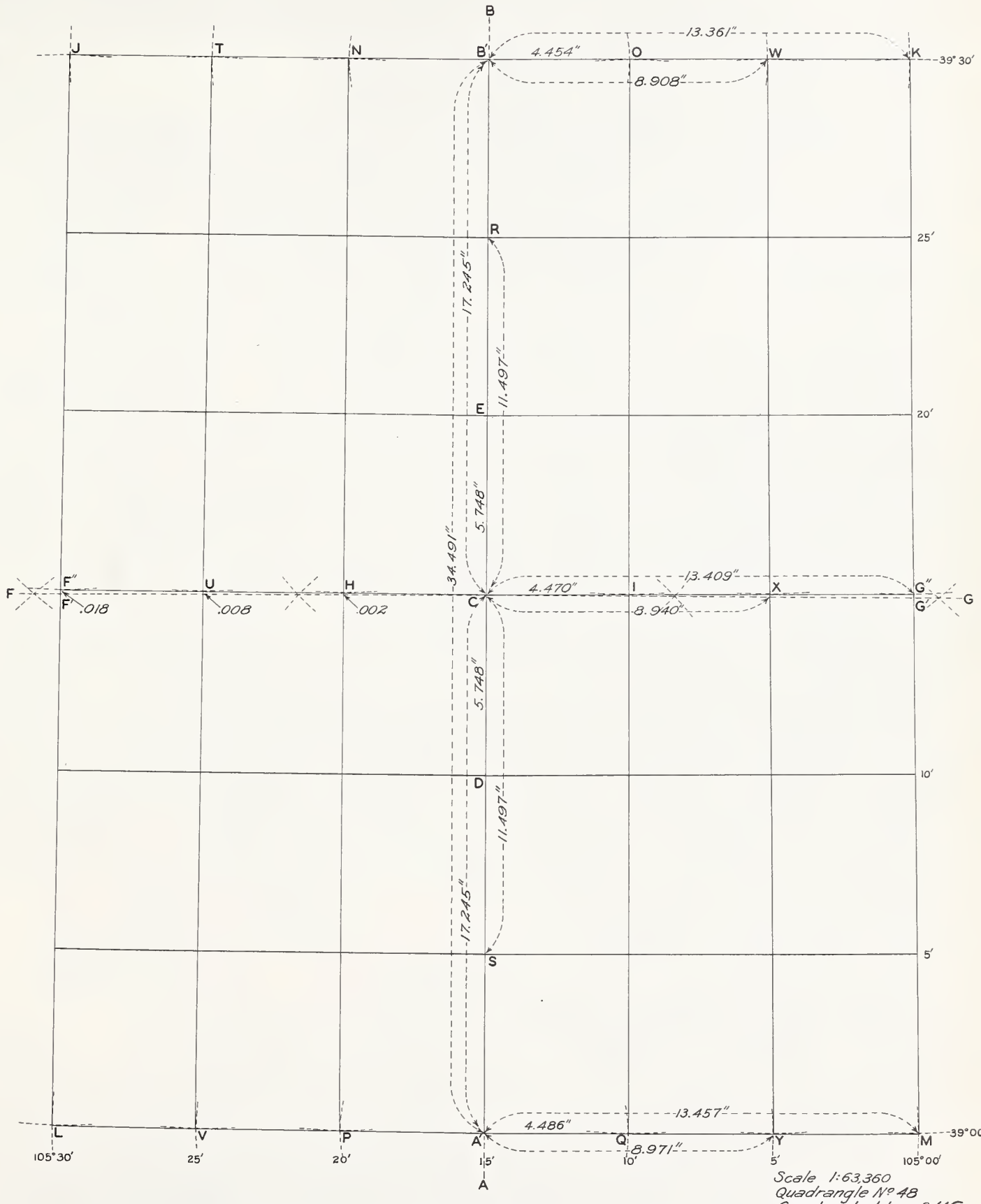
for all equal measurements, thereby strengthening the construction.

Check the construction by measuring over-all distances and by testing corresponding diagonals of all combinations of projection blocks.

Draw the parallels by drawing straight lines between the plotted intersections, as the curvature of the parallels of any standard quadrangle within the limits of this Region is too small to be drawn as a curve. Letter the latitude and longitude as shown on Page I-75, add the scale, the number of the quadrangle, and the initials or name of the person making the construction, and the projection is completed. It should, however, be checked carefully by another person.

In any projection where the ordinate of a developed parallel at the limiting meridian is less than 0.005 inch it is impracticable to plot the curvature, and the parallels should be represented as straight lines perpendicular to the center meridian.

STANDARD PLANE TABLE SHEET



Scale 1:63,360
Quadrangle N° 48
Constructed by JWE
Checked by JWE III

POLYCONIC PROJECTION OF 30-MINUTE QUADRANGLE

TABLE 8.—*Coordinates for projection of maps (scale $\frac{1}{63360}$)*—Continued.

[From Smithsonian Geographical Tables.]

Latitude of parallel.		Meridional distances from even degree parallels.	Abscissas of developed parallel.						Ordinates of developed parallel.		
			5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.			
°	′	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	Longitude interval.	35°	36°
35	00	68.924	4.727	9.454	14.181	18.908	23.636	28.363			
	10	11.489	4.717	9.435	14.152	18.870	23.587	28.305			
	20	22.978	4.708	9.415	14.123	18.831	23.539	28.246			
	30	34.468	4.698	9.396	14.094	18.792	23.490	28.188			
	40	45.957	4.688	9.377	14.065	18.753	23.442	28.130		*Inches.*	*Inches.*
	50	57.446	4.679	9.357	14.036	18.714	23.393	28.072	5	0.002	0.002
									10	.008	.008
36	00	68.935	4.669	9.338	14.007	18.676	23.345	28.014	15	.018	.018
									20	.031	.032
	10	11.491	4.659	9.318	13.977	18.636	23.295	27.954	25	.049	.050
	20	22.983	4.649	9.298	13.947	18.596	23.245	27.894	30	.071	.072
	30	34.474	4.639	9.278	13.917	18.556	23.195	27.835			
	40	45.965	4.629	9.258	13.887	18.517	23.146	27.775			
	50	57.457	4.619	9.238	13.858	18.477	23.096	27.715			
37	00	68.948	4.609	9.219	13.828	18.437	23.046	27.656		37°	38°
	10	11.493	4.599	9.198	13.797	18.396	22.995	27.594			
	20	22.986	4.589	9.178	13.767	18.356	22.944	27.533			
	30	34.480	4.579	9.157	13.736	18.315	22.894	27.472	5	0.002	0.002
	40	45.973	4.568	9.137	13.706	18.274	22.843	27.411	10	.008	.008
	50	57.466	4.558	9.117	13.675	18.234	22.792	27.350	15	.018	.018
									20	.032	.033
38	00	68.959	4.548	9.096	13.645	18.193	22.741	27.289	25	.050	.051
									30	.073	.073
	10	11.495	4.538	9.076	13.613	18.151	22.689	27.227			
	20	22.990	4.527	9.055	13.582	18.109	22.637	27.164			
	30	34.485	4.517	9.034	13.551	18.068	22.585	27.102			
	40	45.980	4.506	9.013	13.520	18.026	22.533	27.039			
	50	57.475	4.496	8.992	13.488	17.984	22.481	26.977		39°	40°
39	00	68.970	4.486	8.971	13.457	17.943	22.429	26.914			
	10	11.497	4.475	8.950	13.425	17.900	22.375	26.851	5	0.002	0.002
	20	22.994	4.464	8.929	13.393	17.858	22.322	26.787	10	.008	.008
	30	34.491	4.454	8.908	13.361	17.815	22.269	26.723	15	.018	.019
	40	45.988	4.443	8.886	13.330	17.773	22.216	26.659	20	.033	.033
	50	57.485	4.433	8.865	13.298	17.730	22.163	26.595	25	.051	.052
									30	.074	.074
40	00	68.982	4.422	8.844	13.266	17.688	22.110	26.532			
	10	11.499	4.411	8.822	13.233	17.644	22.055	26.466			
	20	22.998	4.400	8.800	13.201	17.601	22.001	26.401			
	30	34.497	4.389	8.779	13.168	17.557	21.947	26.336		41°	42°
	40	45.996	4.378	8.757	13.135	17.514	21.892	26.271			
	50	57.495	4.368	8.735	13.103	17.470	21.838	26.206			
41	00	68.994	4.357	8.713	13.070	17.427	21.784	26.140	5	0.002	0.002
									10	.008	.008
	10	11.501	4.346	8.691	13.037	17.383	21.728	26.074	15	.019	.019
	20	23.002	4.335	8.669	13.004	17.338	21.673	26.007	20	.033	.033
	30	34.503	4.324	8.647	12.971	17.294	21.618	25.941	25	.052	.052
	40	46.004	4.312	8.625	12.937	17.250	21.562	25.875	30	.075	.075
	50	57.506	4.301	8.603	12.904	17.205	21.507	25.808			
42	00	69.007	4.290	8.581	12.871	17.161	21.451	25.742			

TABLE 8.—*Coordinates for projection of maps (scale $\frac{1}{63360}$)*—Continued.

[From Smithsonian Geographical Tables.]

Latitude of parallel.	Meridional distances from even degree parallels.	Abscissas of developed parallel.						Ordinates of developed parallel.		
		5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.			
° ′	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	Longitude interval.	42°	43°
42 00	69.007	4.290	8.581	12.871	17.161	21.451	25.742			
10	11.503	4.279	8.558	12.837	17.116	21.395	25.674			
20	23.006	4.268	8.535	12.803	17.071	21.338	25.606			
30	34.510	4.256	8.513	12.769	17.025	21.282	25.538			
40	46.013	4.245	8.490	12.735	16.980	21.225	25.470	′	*Inches.*	*Inches.*
50	57.516	4.234	8.467	12.701	16.935	21.169	25.402	5	0.002	0.002
								10	.008	.008
43 00	69.019	4.222	8.445	12.667	16.890	21.112	25.334	15	.019	.019
								20	.033	.033
10	11.505	4.211	8.422	12.632	16.844	21.054	25.265	25	.052	.052
20	23.010	4.199	8.399	12.598	16.798	20.997	25.196	30	.075	.075
30	34.515	4.188	8.376	12.564	16.751	20.939	25.127			
40	46.020	4.176	8.353	12.529	16.705	20.882	25.058			
50	57.525	4.165	8.330	12.494	16.659	20.824	24.989			
44 00	69.030	4.153	8.307	12.460	16.613	20.767	24.920		44°	45°
10	11.507	4.142	8.283	12.425	16.566	20.708	24.849			
20	23.014	4.130	8.260	12.390	16.519	20.649	24.779			
30	34.522	4.118	8.236	12.354	16.473	20.591	24.709	5	0.002	0.002
40	46.029	4.106	8.213	12.319	16.426	20.532	24.638	10	.008	.008
50	57.536	4.096	8.189	12.284	16.379	20.473	24.568	15	.019	.019
								20	034	.034
45 00	69.043	4.083	8.166	12.249	16.332	20.415	24.498	25	.052	.053
								30	.075	.076
10	11.509	4.071	8.142	12.213	16.284	20.355	24.426			
20	23.018	4.059	8.118	12.177	16.236	20.295	24.354			
30	34.528	4.047	8.094	12.141	16.188	20.236	24.283			
40	46.037	4.035	8.070	12.105	16.141	20.176	24.211			
50	57.546	4.023	8.046	12.070	16.093	20.116	24.139		46°	47°
46 00	69.055	4.011	8.023	12.034	16.045	20.056	24.068			
10	11.511	3.999	7.998	11.997	15.997	19.996	23.995	5	0.002	0.002
20	23.023	3.987	7.974	11.961	15.948	19.935	23.922	10	.008	.008
30	34.534	3.975	7.950	11.925	15.899	19.874	23.849	15	.019	.019
40	46.045	3.963	7.925	11.888	15.851	19.813	23.776	20	.034	.034
50	57.557	3.951	7.901	11.852	15.802	19.753	23.703	25	.053	.052
								30	.076	.075
47 00	69.068	3.938	7.877	11.815	15.754	19.692	23.630			
10	11.513	3.926	7.852	11.778	15.704	19.630	23.556			
20	23.027	3.914	7.827	11.741	15.655	19.569	23.482			
30	34.540	3.901	7.803	11.704	15.606	19.507	23.408			
40	46.053	3.889	7.778	11.667	15.556	19.445	23.334		48°	49°
50	57.567	3.877	7.753	11.630	15.507	19.383	23.260			
48 00	69.080	3.864	7.729	11.593	15.457	19.322	23.186	5	0.002	0.002
								10	.008	.008
10	11.516	3.852	7.704	11.555	15.407	19.259	23.111	15	.019	.019
20	23.031	3.839	7.679	11.518	15.357	19.196	23.035	20	.033	.033
30	34.546	3.827	7.653	11.480	15.307	19.134	22.960	25	.052	.052
40	46.062	3.814	7.628	11.442	15.257	19.071	22.885	30	.075	.075
50	57.577	3.802	7.603	11.405	15.206	19.008	22.810			
49 00	69.093	3.789	7.578	11.367	15.156	18.945	22.734			

CONVERSION OF SLOPE DISTANCES TO HORIZONTAL DISTANCES

[Percent Abney and 100-foot tape]

Slope distance, feet	Per cent																		
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
2	2.0	2.0	2.0	1.9	1.9	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.6	1.6	1.6	1.5	1.5	1.5	1.4
4	4.0	4.0	3.9	3.9	3.8	3.8	3.7	3.6	3.6	3.5	3.4	3.4	3.3	3.2	3.1	3.0	3.0	2.9	2.8
6	6.0	5.9	5.9	5.8	5.7	5.7	5.6	5.5	5.4	5.3	5.1	5.0	4.9	4.8	4.7	4.6	4.5	4.4	4.2
8	8.0	7.9	7.8	7.8	7.7	7.6	7.4	7.3	7.2	7.0	6.9	6.7	6.6	6.4	6.2	6.1	5.9	5.8	5.7
10	10.0	9.9	9.8	9.7	9.6	9.4	9.3	9.1	8.9	8.8	8.6	8.4	8.2	8.0	7.8	7.6	7.4	7.3	7.1
12	11.9	11.9	11.8	11.6	11.5	11.3	11.1	10.9	10.7	10.5	10.3	10.1	9.8	9.6	9.4	9.1	8.9	8.7	8.5
14	13.9	13.8	13.7	13.6	13.4	13.2	13.0	12.8	12.5	12.3	12.0	11.7	11.2	11.2	10.9	10.7	10.4	10.2	9.9
16	15.9	15.8	15.7	15.5	15.3	15.1	14.9	14.6	14.3	14.0	13.7	13.4	13.1	12.8	12.5	12.2	11.9	11.6	11.3
18	17.9	17.8	17.7	17.5	17.2	17.0	16.7	16.4	16.1	15.8	15.4	15.1	14.7	14.4	14.1	13.7	13.4	13.1	12.7
20	19.9	19.8	19.6	19.4	19.2	18.9	18.6	18.2	17.9	17.5	17.1	16.8	16.4	16.0	15.6	15.2	14.9	14.5	14.1
22	21.9	21.8	21.6	21.3	21.1	20.8	20.4	20.1	19.7	19.3	18.9	18.4	18.0	17.6	17.2	16.8	16.4	15.9	15.6
24	23.9	23.7	23.5	23.3	23.0	22.7	22.3	21.9	21.5	21.0	20.6	20.1	19.7	19.2	18.7	18.3	17.8	17.4	17.0
26	25.9	25.7	25.5	25.2	24.9	24.5	24.1	23.7	23.3	22.8	22.3	21.8	21.3	20.8	21.3	19.8	19.3	19.8	18.4
28	27.9	27.7	27.5	27.2	26.8	26.4	26.0	25.5	25.0	24.5	24.0	23.5	22.4	22.9	21.9	21.3	20.8	20.3	19.8
30	29.9	29.7	29.4	29.1	28.7	28.3	27.9	27.4	26.8	26.3	25.7	25.2	24.6	24.0	23.4	22.9	22.3	21.7	21.2
32	31.8	31.6	31.4	31.0	30.7	30.2	29.7	29.2	28.6	28.0	27.4	26.8	26.2	25.6	25.0	24.4	23.8	23.2	22.6
34	33.8	33.6	33.3	33.0	32.6	32.1	31.6	31.0	30.4	29.8	29.2	28.5	27.9	27.2	26.5	25.9	25.3	24.6	24.0
36	35.8	35.6	35.3	34.9	34.5	34.0	33.4	32.8	32.2	31.5	30.9	30.2	29.5	28.8	28.1	27.4	26.8	26.1	25.5
38	37.8	37.6	37.3	37.0	36.4	35.9	35.3	34.7	34.0	33.3	32.6	31.9	31.1	30.4	29.7	29.0	28.2	27.5	26.9
40	39.8	39.6	39.2	38.8	38.3	37.8	37.1	36.5	35.8	35.0	34.3	33.5	32.8	32.0	31.2	30.5	29.7	29.0	28.3
42	41.8	41.5	41.2	40.7	40.2	39.6	39.0	38.3	37.6	36.8	36.0	35.2	34.4	33.6	32.8	32.0	31.2	30.4	29.7
44	43.8	43.5	43.1	42.7	42.1	41.5	40.9	40.1	39.4	38.6	37.7	37.9	36.0	35.2	34.4	33.5	32.7	31.9	31.1
46	45.8	45.5	45.1	44.6	44.1	43.4	42.7	41.9	41.1	40.3	39.4	38.6	37.7	36.8	35.9	35.0	34.2	33.3	32.5
48	47.8	47.5	47.1	46.6	46.0	45.3	44.6	43.8	42.9	42.1	41.2	40.2	39.3	38.4	37.5	36.6	35.7	34.8	33.9
50	49.8	49.4	49.0	48.5	47.9	47.2	46.4	45.6	44.7	43.8	42.9	41.9	41.0	40.0	39.0	38.1	37.2	36.2	35.4
52	51.7	51.4	51.0	50.4	49.8	49.1	48.3	47.4	46.5	45.6	44.6	43.6	42.6	41.6	40.6	39.6	38.7	37.7	36.8
54	53.7	53.4	53.0	52.4	51.7	51.0	50.1	49.2	48.3	47.3	46.3	45.3	44.2	43.2	42.2	41.1	40.1	39.1	38.2
56	55.7	55.4	54.9	54.3	53.6	52.9	52.0	51.1	50.1	49.1	48.0	47.0	45.9	44.8	43.7	42.7	41.6	40.6	39.6
58	57.7	57.4	56.9	56.3	55.6	54.7	53.9	52.9	51.9	50.8	49.7	48.6	47.5	46.4	45.3	44.2	43.1	42.0	41.0
60	59.7	59.3	58.8	58.2	57.5	56.6	55.7	54.7	53.7	52.6	51.4	50.3	49.1	48.0	46.8	45.7	44.6	43.5	42.4
62	61.7	61.3	60.8	60.1	59.4	58.5	57.6	56.5	55.5	54.3	53.2	52.0	50.8	49.6	48.4	47.2	46.1	44.9	43.8
64	63.7	63.3	62.8	62.1	61.3	60.4	59.4	58.4	57.2	56.1	54.9	53.7	52.4	51.2	50.0	48.8	47.6	46.4	45.3
66	65.7	65.3	64.7	64.0	63.2	62.3	61.3	60.2	59.0	57.8	56.6	55.3	54.1	52.8	51.5	50.3	49.1	47.8	46.7
68	67.7	67.2	66.7	66.0	65.1	64.2	63.1	62.0	60.8	59.6	58.3	57.0	55.7	54.4	53.1	51.8	50.5	49.3	48.1
70	69.7	69.2	68.6	67.9	67.0	66.1	65.0	63.8	62.6	61.3	60.0	58.7	57.3	56.0	54.7	53.3	52.0	50.7	49.5
72	71.6	71.2	70.6	69.9	69.0	68.0	66.9	65.7	64.4	63.1	61.7	60.4	59.0	57.6	56.2	54.9	53.5	52.2	50.9
74	73.6	73.2	72.6	71.8	70.9	69.8	68.7	67.5	66.2	64.8	63.5	62.0	60.6	59.2	57.8	56.4	55.0	53.6	52.3
76	75.6	75.2	74.5	73.7	72.8	71.7	70.6	69.3	68.0	66.6	65.2	63.7	62.3	60.8	59.3	57.9	56.5	55.1	53.7
78	77.6	77.1	76.5	75.7	74.7	73.6	72.4	71.1	69.8	68.3	66.9	65.4	63.9	62.4	60.9	59.4	58.0	56.5	55.2
80	79.6	79.1	78.4	77.6	76.6	75.5	74.3	73.0	71.6	70.1	68.6	67.1	65.5	64.0	62.5	61.0	59.5	58.0	56.6
82	81.6	81.1	80.4	79.6	78.5	77.4	76.1	74.8	73.3	71.9	70.3	68.8	67.2	65.6	64.0	62.5	61.0	59.4	58.0
84	83.6	83.1	82.4	81.5	80.5	79.3	78.0	76.6	75.1	73.6	72.0	70.4	68.8	67.2	65.6	64.0	62.4	60.9	59.4
86	85.6	85.0	84.3	83.4	82.4	81.2	79.9	78.4	76.9	75.4	73.7	72.1	70.4	68.8	67.1	65.5	53.9	62.3	60.8
88	87.6	87.0	86.3	85.4	84.3	83.1	81.7	80.2	78.7	77.1	75.5	73.8	72.1	70.4	68.7	67.0	65.4	63.8	62.2
90	89.6	89.0	88.3	87.3	86.2	85.0	83.6	82.1	80.5	78.9	77.2	75.5	73.7	72.0	70.3	68.6	66.9	65.2	63.6
92	91.5	91.0	90.2	89.3	88.1	86.8	85.4	83.9	82.3	80.6	78.9	77.1	75.4	73.6	71.8	70.1	68.4	66.7	65.1
94	93.5	93.0	92.2	91.2	90.0	88.7	87.3	85.7	84.1	82.4	80.6	78.8	77.0	75.2	73.4	71.6	69.9	68.1	66.5
96	95.5	94.9	94.1	93.1	92.0	90.6	89.1	87.5	85.9	84.1	82.3	80.5	78.6	76.8	75.0	73.1	71.4	69.6	67.9
98	97.5	96.9	96.1	95.1	93.9	92.5	91.0	89.4	87.7	85.9	84.0	82.2	80.3	78.4	76.5	74.7	72.8	71.0	69.3
100	99.5	98.9	98.1	97.0	95.8	94.4	92.8	91.2	89.4	87.6	85.7	83.8	81.9	80.0	78.1	76.2	74.3	72.5	70.7

INTERVISIBILITY OF STATIONS (As given by the U. S. Coast and Geodetic Survey)

Reconnaissance of triangulation can be executed by either of two general methods, or by a combination of them. In the first method, which can be used in hilly or mountainous country, the intervisibility of the stations is tested by visiting each station. In the second method reliance is placed upon obtaining the elevations of the stations and of the intervening country from maps or other sources and determining the intervisibility of points and the required heights of towers from those data. This second method is necessary in flat country. In actual practice a combination of the two methods is generally used.

The difference between the apparent and true difference in elevation of two points is affected by two factors - the curvature of the earth's surface and the refraction of light by the earth's atmosphere. These factors are of opposite sign and of an approximately fixed relation to each other, so that the combined effect can be applied as a single factor. The effect of refraction is about one-seventh as much as the curvature. The formulas for the separate effect of each can be found in various works on geodetic surveying, but the formulas below give the approximate resultant:

$$h \text{ (in feet)} = K^2 \text{ (in miles) times } 0.574,$$

or $$K \text{ (in miles)} = \sqrt{h \text{ (in feet)}} \text{ times } 1.32.$$

Below is a table, condensed from the one given in Appendix 9, Report for 1882, which gives the distance K (in

statute miles) at which a line from the height h (in feet) will touch the horizon, taking into account terrestrial refraction with a mean assumed coefficient of refraction of 0.070.

CORRECTION FOR EARTH'S CURVATURE AND REFRACTION

Distance	Correction	Distance	Correction	Distance	Correction	Distance	Correction
Miles	Feet	Miles	Feet	Miles	Feet	Miles	Feet
1	0.6	16	146.9	31	551.4	46	1,214.2
2	2.3	17	165.8	32	587.6	47	1,267.7
3	5.2	18	185.9	33	624.9	48	1,322.1
4	9.2	19	207.2	34	663.3	49	1,377.7
5	14.4	20	229.5	35	703.0	50	1,434.6
6	20.6	21	253.1	36	743.7	51	1,492.5
7	28.1	22	277.7	37	785.6	52	1,551.6
8	36.7	23	303.6	38	828.6	53	1,611.9
9	46.4	24	330.5	39	872.8	54	1,673.3
10	57.4	25	358.6	40	918.1	55	1,735.8
11	69.4	26	388.0	41	964.7	56	1,799.6
12	82.7	27	418.3	42	1012.2	57	1,864.4
13	97.0	28	449.9	43	1061.0	58	1,930.4
14	112.5	29	482.6	44	1111.0	59	1,997.5
15	129.1	30	516.4	45	1162.0	60	2,065.8

To determine how much the line of sight between two stations will clear or fail to clear an intervening hill, either the table above may be used or the following formula employed:

$$h = h_1 + (h_2 - h_1) \frac{d_1}{d_1 + d_2} - 0.574 d_1 d_2,$$

where

h = height of line at obstruction, in feet.

h_1 = height of lower station, in feet.

h_2 = height of higher station, in feet.

d_1 = distance from lower station to intervening obstruction, in miles

d_2 = distance from intervening obstruction to higher station, in miles.

This formula is also based on a mean assumed coefficient of refraction of 0.070.

Computation for the Determination of the Invervisibility of Stations: A few examples will be given to illustrate the application of the formulas relating to curvature and refraction.

Example:

Two stations are at the water's level on opposite shores of a bay 18 miles wide. In this problem the line of sight is not supposed to approach the water nearer than 10 feet.

(a) How high above the water must the instrument be at Station A with the instrument at Station B 10 feet above the surface?

(b) How high must the towers be, supposing them to be of equal height at the two stations?

Solution of (a): From the table for curvature and refraction, Page I-82, the instrument must be at an elevation of 185.9 feet for the line of sight, to be tangent to the earth's surface at a distance of 18 miles. Since it must not approach the water surface nearer than 10 feet at station B, the instrument at A must be 195.9 feet above the water surface. (See Fig. 1 Page I-89.)

(Solution of (b): Since the towers are to be of equal height, the line of sight will approach the water the nearest at a point midway between the two stations. From the table the instrument must be elevated 46.4 feet to see the water surface 9 miles distant. Since the line of sight must clear the surface by 10 feet, the instrument must be elevated 56.4 feet at each station. (See Fig. 2 Page I-89.) Or, by the formula:

$$h \text{ (in feet)} = K^2 \text{(in miles)} \times 0.574,$$

$$h = 81 \times 0.574 = 46.49 \text{ feet},$$

$$46.49 + 10 = 56.49 \text{ feet}.$$

Example:

A level plain is wooded with trees 35 feet high. It is desirable that the line of sight clear the trees by 10 feet at least.

(a) With towers 70 feet high, without superstructure - that is, with lamp and theodolite mounted at same height - what is the maximum length of line?

(b) Under the same conditions of terrain, what is the maximum length of line when the theodolite is at a height of 70 feet and the lamp at a height of 90 feet above the ground?

Solution of (a): Since the line of sight must not approach nearer than 45 feet to the surface of the plain or 10 feet above the tree tops, and the towers are 70 feet high,

the problem is the same as if the towers were 70-45 feet high and the line of sight could be tangent to the surface of a level plain. From the table it is seen that the line of sight from a tower 25 feet high would be tangent to the surface of the sphere at a distance between 6 and 7 miles.

Applying the Formula

$$h \text{ (in feet)} = K^2 \text{ (in miles)} \times 0.574$$

$$K^2 = \frac{25}{0.574}$$

or $K = 6.6$ miles

The stations could, therefore, be 13.2 miles apart. (See Fig. 3 Page I-89.)

Solution of (b): From the previous example the line of sight from a tower 70 feet high is tangent to the spherical surface 45 feet above the station at a distance of 6.6 miles. The distance at which the line of sight from the 90-foot tower will be tangent to the 45-foot surface is found from the formula in a similar manner as follows:

$$(90-45) = h = K^2 \times 0.574$$

$$K^2 = \frac{45}{0.574}$$

or $K = 8.9$ miles

Therefore, the maximum distance between stations would be 6.6 + 8.9 = 15.5 miles. (See Fig. 4 Page I-89.)

When contoured maps of a hilly or mountainous country are available, they are of great assistance in reconnaissance. When laying out a scheme from a map the most frequent problem is to determine if a certain ridge or mountain between two

stations will cut the line of sight, and if so, if it will be practicable to build at either station and thus make the stations intervisible. Such a problem may be solved either by the formula on the preceding page or by the table for curvature and refraction. A solution of such a problem by each method is given below.

Example:

Two stations, A and B, are 54 miles apart and at an elevation above sea level of 1,050 and 4,500 feet, respectively. At X on the line between A and B and at a distance of 18 miles from A is a ridge 1,840 feet high. (See Fig. 5 Page I-90.)

(a) How much below the crest of the ridge does the line between stations strike?

(b) Supposing a tower is to be built at only one station, what height would be necessary at each station for the line of sight to barely clear the ridge?

Solution of (a): At 18 miles, the distance from A to X (Fig. 5 Page I), the correction for curvature and refraction is 185.9 feet and 54 miles, the distance from A to B, it is 1,673.3 feet. Subtracting these amounts from the elevations of X and B, respectively, will have the effect of reducing the sea-level bases of A, X, and B to a plane surface.

Therefore, in Fig. 6 Page I-90

bc=4,500 feet - 1,050 feet - 1,673.3 feet

= 1,776.7 feet,

and ed: bc : : 18 : 54

Therefore ed = 592.2 feet

Correcting elevation of X for curvature and refraction and reducing it to the plane of peak A

X = 1,840 - 1,050 - 185.9

= 604.1 feet

Since the line of sight from A to B, at a point 18 miles from A, is only 592.2 feet above A, therefore the line of sight fails to clear peak X by 604.1 - 592.2 = 11.9 feet.

Another method for obtaining the elevation at X of the straight line between the two stations is by the formula given below:

$$h=h_1+(h_2-h_1)\frac{d_1}{d_1+d_2}-0.574\ d_1\ d_2$$

In which the example given above

$$h_1 = 1{,}050,\ h_2 = 4{,}500,\ d_1 = 18,\ d_2 = 36$$

Substituting these values

$$h = 1{,}050 + (4{,}500 - 1{,}050)\ \frac{18}{18+36} - 0.574$$

$$\times 18\times 36 = 1{,}828$$

Therefore, the line between A and B is 12 feet below the top of the ridge.

There may be times in the field when the observer will not have a book at hand from which to obtain the formula for the second method and he may not be able to recall the formula. He may use the first method, however, if he merely remembers

that the correction in feet for curvature and refraction is the square of the distance in miles times 0.574. The second method may be a little easier as regards the numerical operations.

Solution of (b): Accepting 1,328 feet as the elevation at X of the line from A to B, the line strikes 12 feet below the crest of the ridge. If the station at A is to be elevated, the necessary height can be computed by means of a triangle, as shown in Figure 7 Page I-90. The line from A to B has already been corrected for curvature and refraction.

Let AA' be the height by which A is to be increased. From similar triangles

AA' : XX' : : AB = XB,

or AA' : 12 : : 54 : 36

Therefore AA' = 18 feet

If the station at B is to be elevated, a similar method may be used as shown in Figure 8 Page I-90.

BB' : 12 : : 54 : 18.

Therefore BB' = 36 feet.

These two solutions show that, other things being equal, it is always more economical to build at the station nearest the obstruction, for the height necessary to clear the obstruction increases in direct proportion to the distance from it.

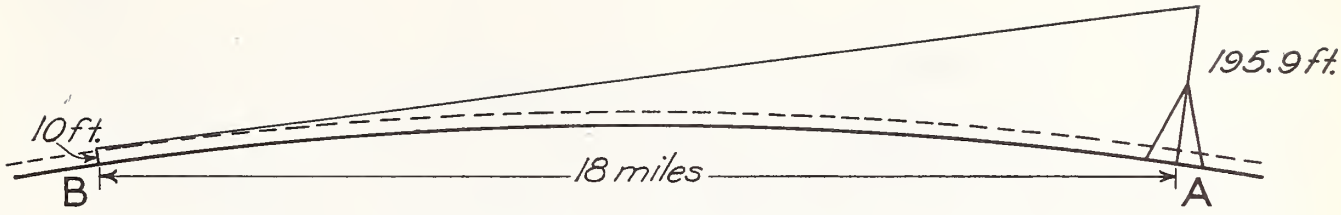


FIG. 1 – INTERVISIBILITY OF STATIONS ACROSS WATER

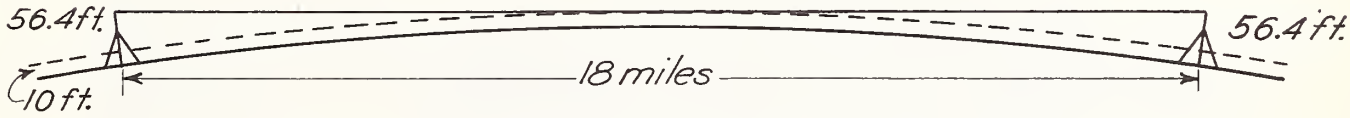


FIG. 2 – INTERVISIBILITY OF STATIONS ACROSS WATER

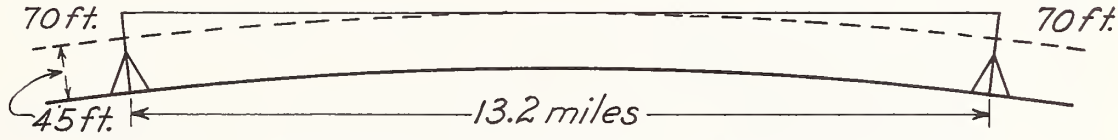


FIG. 3 – INTERVISIBILITY OF STATIONS ACROSS WOODED PLAIN

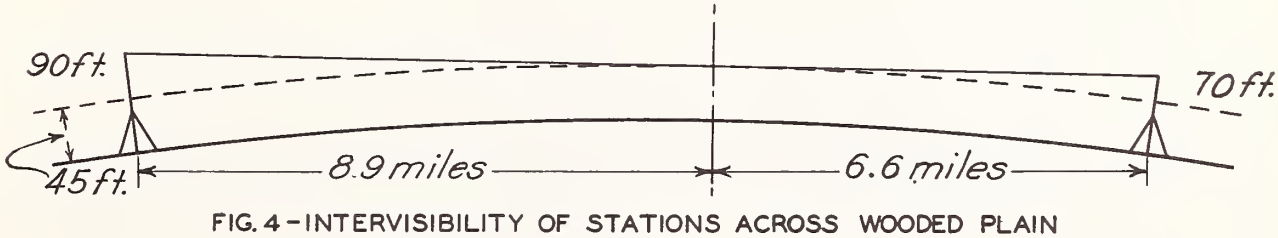


FIG. 4 – INTERVISIBILITY OF STATIONS ACROSS WOODED PLAIN

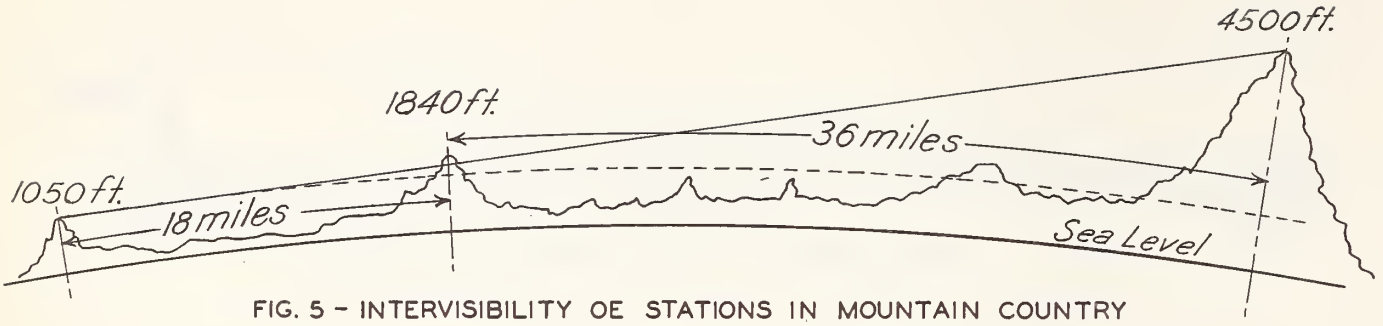


FIG. 5 - INTERVISIBILITY OE STATIONS IN MOUNTAIN COUNTRY

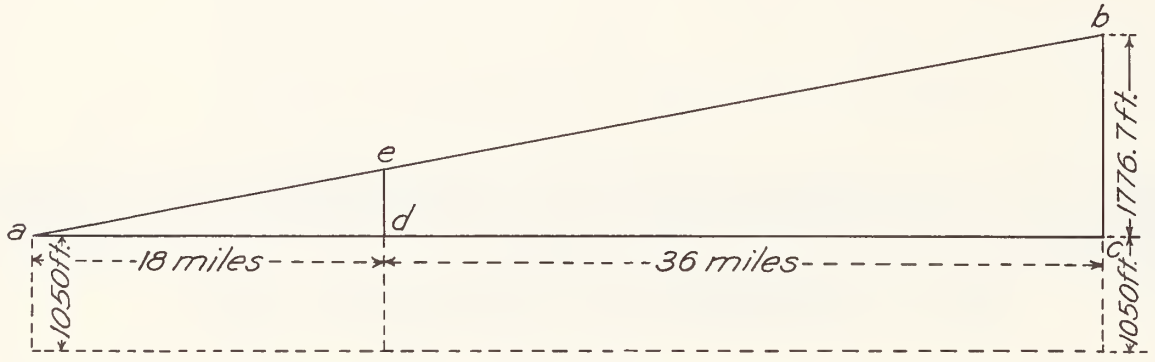


FIG. 6 - INTERVISIBILITY OF STATIONS IN MOUNTAIN COUNTRY

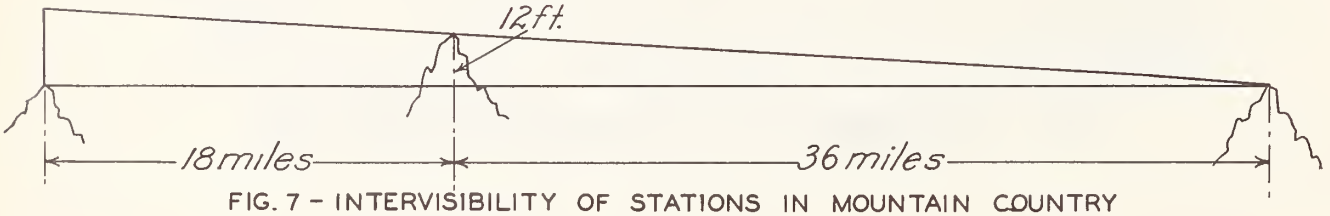


FIG. 7 - INTERVISIBILITY OF STATIONS IN MOUNTAIN COUNTRY

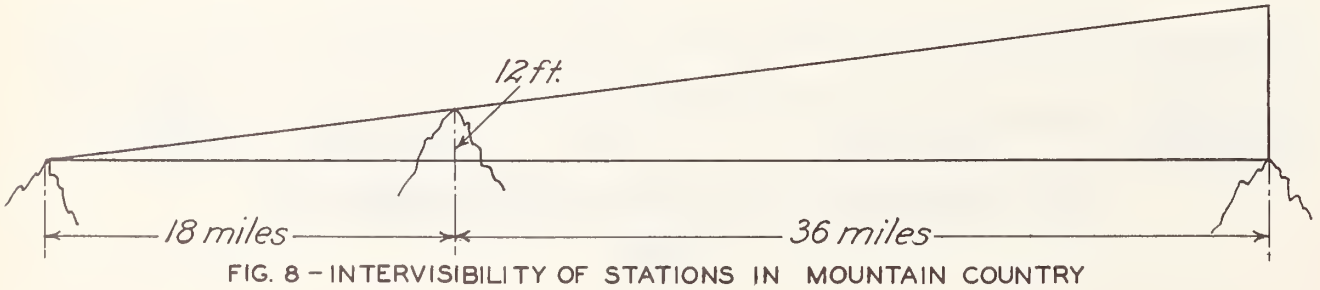
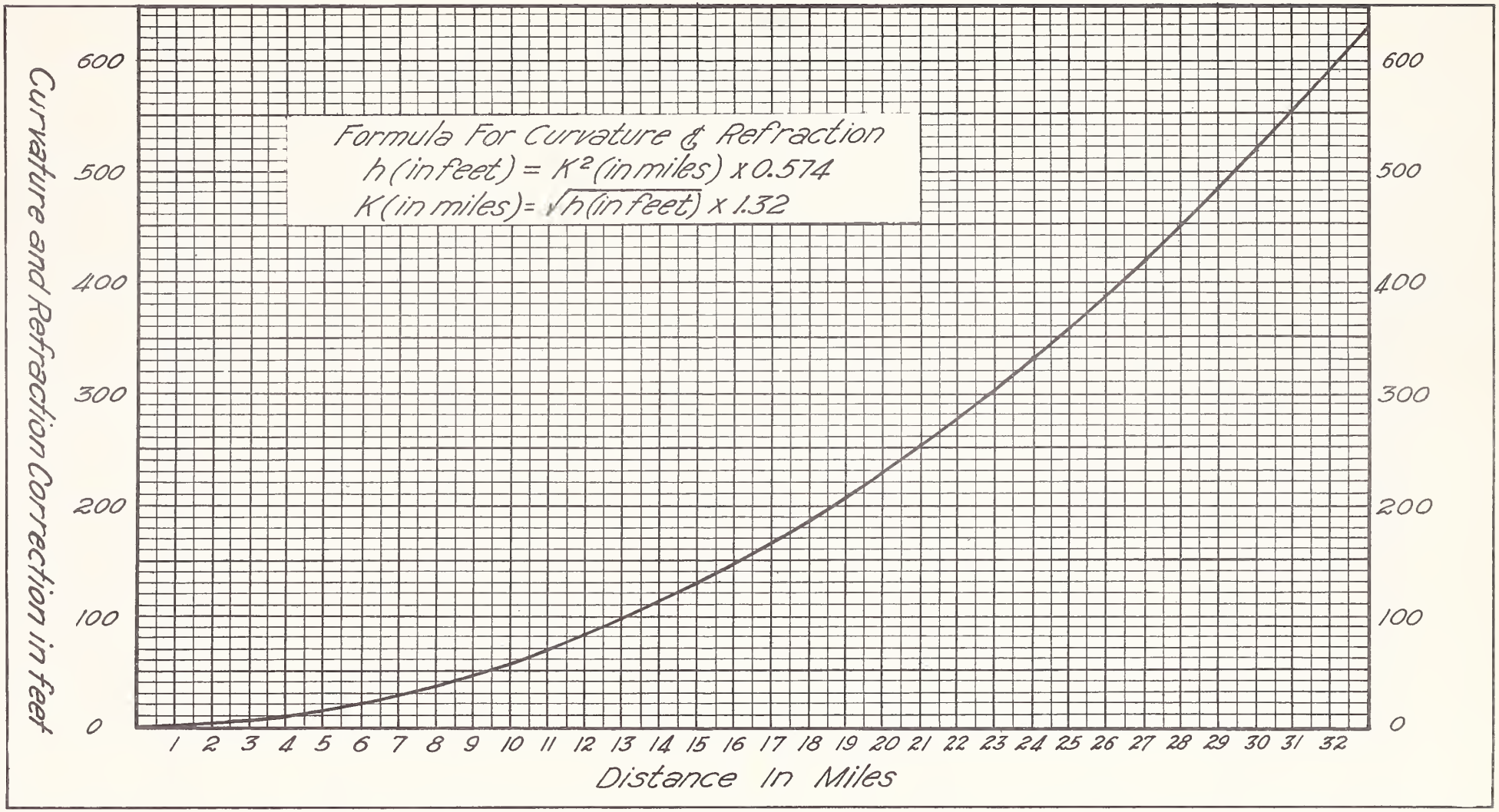


FIG. 8 - INTERVISIBILITY OF STATIONS IN MOUNTAIN COUNTRY


Formula For Curvature & Refraction
h (in feet) = K² (in miles) x 0.574
K (in miles) = √h (in feet) x 1.32
Curvature and Refraction Correction in feet
0
100
200
300
400
500
600
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Distance In Miles

SECTION CORNER MARKINGS:

All section corners of townships surveyed before 1906 were perpetuated with stones or wood posts. The posts were marked with notches on certain edges which made the location of the corner in the township possible. The township diagram on Page I-95 shows the system used.

Some of the earlier instructions were rather flexible. A paragraph in the original survey notes stating that "--a stone 6"x10"x15" was set in a mound of stone" indicates just that - no marks were used. Marks chiseled on a stone 50 years ago may not be pplain, lichens may be growing over them. If marks were in hard rock they no doubt will be legible. Wooden posts will be down and badly decayed, and if fire has passed over the area they might even be destroyed. If rocks are planeiful in the vicinity a rock probably was used to mark a corner.

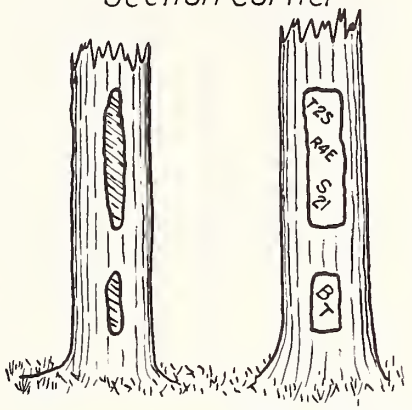
Both new surveys and resurveys of townships by the General Land Office are perpetuated by the use of iron posts at section corners with bronze caps, upon which are marked the section, township, range and year. The retracement, finding and identifications of these corners seldom present a problem.

See the chart on page I-96 for corner marking of recent General Land Office survey and resurveyed townships.

DIAGRAM SHOWING OLD SYSTEM OF MARKING CORNERS

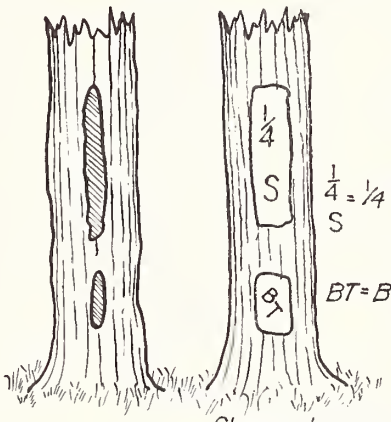
Witness trees for ¼ & section corners are marked similar to the diagrams below.

Witness Tree Section Corner



Scar grown over *Chopped open to show markings*

Witness Tree ¼ Corner

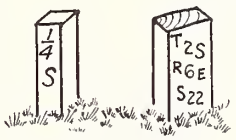


¼ = ¼ Section
S

BT = Bearing Tree

Scar grown over *Chopped open to show markings*

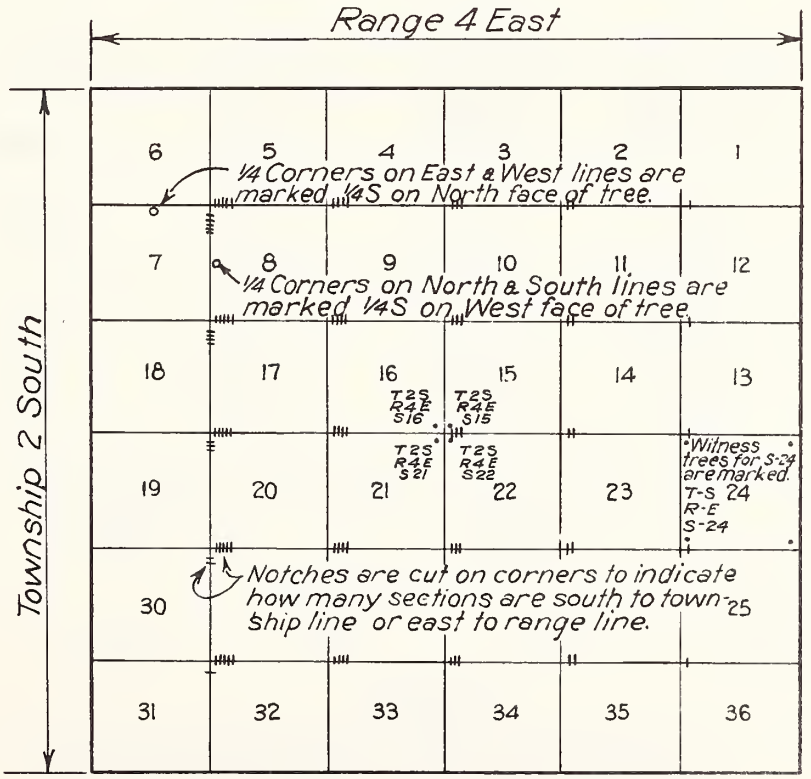
Rock



Wooden stakes

Corners are marked with one of the above

Note:- Section corners should be officially marked only by authorized members of the G.L.O.



Note: ¼S means ¼ Section corner

Dec-39 GG.M. *Revised F.E.W* *Courtesy of the G. L. O.*

DIAGRAM SHOWING REVISED SYSTEM OF MARKING CORNERS

Stondord Tp.Cor.
3 inch
SC
T 25 N
R 17 E | R 18 E
S 36 | S 31
1913

C.C. on Stond. Parallel
3 inch
T 25 N
R 17 W
UTAH | S 32 CC
1913

Closing Tp. Cor.
3 inch
T25N R17E
S 36
S1 | S6
R17E | R18E
T24N
CC
1913

Closing Tp. Cor.
3 inch
T24N
T24N | R17E
S 36 | S 31 CC
S 6
R16E | T23N
1913

Closing Tp. Cor.
3 inch
T24N
R16E | T24N
CC S36 | S31
S1
T23N | R17E
1913

C.C. on Reservation Bdy.
3 inch
T25N
CC S 33 BIR
S 4
T 24 N
R17E
1913

C.C. on Reservation Bdy
3 inch
BIR
S 13 | S 18
R17E | R18E
T 24 N
C C
1913

Cor. of 4 Tps.
3 inch
T25N
R17E | R18E
S36 | S 31
S1 | S6
T 24 N
1913

Cor. of 2 Tps.
3 inch
T3 N
R7 W
S 36
S1
T2 N
1913

Cor. of 1 Tp.
3 inch
T23 N
R7 W
S 36
1913

Stondord Sec. Cor.
3 inch
SC
T25N | R17E
S35 | S36
1913

Closing Sec. Cor.
2 inch
T25N R17E
S 35
S2 | S1
T24N | R17E
CC
1913

Cor. of 4 Secs. on Range Line.
3 inch
T25N
R17E | R18E
S12 | S7
S13 | S18
1913

Cor. of 4 Secs. on Tp. Line
3 inch
T26 N | R17E
S35 | S36
S2 | S1
T25N
1913

Cor. of 4 Secs. Interior.
2 inch
T25N | R17E
S23 | S24
S26 | S25
1913

Cor. of 2 Secs. on Range Line.
3 inch
T 14 S
S 12
S 13
R17E
1913

Cor. of 2 Secs. on Tp. Line
3 inch
T27N | R17W
S31 | S32
1913

Cor. of 2 Secs. Interior
2 inch
T14S | R20W
S10 | S11
1913

Cor. of 2 Secs. Interior.
2 inch
T27N
S15
S22
R14W
1913

Cor. of 1 Sec.
2 inch
T27N
R16W
S17
1913

Stond. 1/4 Sec. Cor.
1 inch
SC
1/4 S 36
1913

C.C. on 1/4 Sec. Line
1 inch
PL
1/4
S | 5
BIR 1/4
CC
1913

1/4 Sec. Cor.
1 inch
1/4
S 13 | S 18
1913

1/4 Sec. Cor.
1 inch
1/4 S 21
S 28
1913

1/4 Sec. Cor. Common to 2 quorters of 1 Sec.
1 inch
1/4 S 16
1913

Center 1/4 Cor.
1 inch
C 1/4 S 29
1913

Stond. 1/16 Cor.
1 inch
SC
W 1/16 S 31
1913

C.C. on 1/16 Line
1 inch
CC S 14 | SPL
BIR 1/16
1913

1/16 Sec. Cor.
1 inch
W 1/16 S 33
S 4
1913

1/16 Sec. Cor.
1 inch
N 1/16
S 13 | S 18
1913

1/16 Sec. Cor.
1 inch
SW 1/16 S 27
1913

M.C. on Stond. Line
3 inch
T25N
R17E
MC | S 33
1913

M.C. on Range Line.
3 inch
MC
S 13 | S 18
R17E | R18E
T24N
1913

M.C. on Range Line
3 inch
T24N
R17E | R18E
S 13 | S 18
MC
1913

M.C. on Tp. Line
3 inch
T25N
R17W | S 35 | MC
S 2
T24N
1913

M.C. on Tp. Line.
3 inch
T25N
MC | S 35 | R17W
S 2
T24N
1913

M.C. on Sec. Line
2 inch
MC
S 26 | S 25
T25N | R17E
1913

M.C. on Sec. Line.
2 inch
T25N R17E
S26 | S25
MC
1913

M.C. on Sec. Line.
2 inch
T25N
MC | S 23
S 26
R17E
1913

M.C. on Sec. Line
2 inch
T25N
S 26
S 35 | MC
R17E
1913

M.C. on 1/4 Sec. Line.
1 inch
MC
1/4
S | 30
1/4
1913

M.C. on ,, Sec. Line.
1 inch
N | S 30 | NMC
1/16
1913

Mon. on Unsurveyed Land.
3 inch
BIR
3M | PL
1913

Mon. on Surveyed Land
3 inch
T25N
R17W
BIR | S23
3M
1913

Angle Pt. with Serial No.
3 inch
T27N
S13 | AP4
R17W | BIR
1913

Angle Pt. without Serial No.
3 inch
AP
T12S R90W
S 33
1913

Cor. of Private Claim
1 inch
T16N R7E
S14 | 2
TR37
1913

LEGEND

SC for Standard Cor., on N. half of cap. CC for Closing Cor., on half from which closing is made. WC for Witness Cor., on half of cap toward true point for corner. Witness Corners will be marked exactly as if set at true point, with WC added. Letters and figures will be stamped to be read from the South side of post.

BIR = *Blackfeet Indian Reservation.*

Courtesy of G.L.O.

S E C T I O N J

COMPILATION OF PLANIMETRIC MAPS

The compilation of planimetric maps is a highly technical procedure and must be performed by cartographers and draftsmen skilled in this work. The compilation of planimetric maps will be under the general supervision of the Chief of Drafting, and under the direct supervision of a cartographer in charge of this work. The number of men employed will be determined entirely by the appropriations available and the amount of work to be accomplished. However, for the greatest amount of efficiency, these instructions are written around what appears to be a nucleus for this class of work; namely, 6 draftsmen and cartographers under the direct supervision of a cartographer in charge of the work. Their duties are controlling photographs, making templets, detailing photographs, laying photo triangulation, transfer of detail by reflecting projector, compiling land net, and editing. When the organization is operating with this nucleus each man should be so trained that he can perform one of these duties efficiently, but he shall also be able to assist in any of the other duties. By so doing this will prevent the work from forming a bottle neck, and at the same time develop the ability of each man.

The cartographer in charge will receive his orders directly from the Chief Draftsman, and will consult with him and the Chief of Surveys and Maps on all problems pertaining to the accuracy and priority of work or other problems which may arise. All other personnel assigned to this work will

receive orders from and report directly to the cartographer in charge and shall adhere to the following instructions.

Photographs

When a project is undertaken, two sets of photographs on double weight matte or semi-matte paper will be printed and delivered to the file clerk. One set will be labeled "Control" and the other "Detail." Extreme care should be taken in the handling of these photographs to prevent breakage or their becoming lost as the information on them is of vital importance.

Since there are two sets of photographs involved in the construction of planimetric maps, these instructions are written first following through with the Control photographs and then with the Detail photographs up to the point of convergence of the two operations.

Control Photographs: The set of control prints will first be furnished to the field engineer and will be used for identification of field control. They will later be used for picking control points by the cartographers for radial line work and the making of templets, and used by the field Inspector for corrections. These control photographs are to be used for no other purpose.

Detail Photographs: The set of detail photographs will be kept in the files under "Detail Photographs" and will be identical in every respect to the control set of photographs, but will be used for detailing only and will be clearly labeled "Detail Prints."

Photo Control

Picking Tie Points: The first step in this operation will necessitate the establishment of a number of uniformly spaced control points supplementing and augmenting the field control. The first of these to be established is a thorough set of "tie points." A "tie point" is a point picked midway in the sidelap common to two adjacent strips of photographs. As these points are of primary importance in tying the whole assembly together it is necessary that the utmost accuracy be used in their picking. Whenever possible, three "tie points" per picture uniformly spaced in a north and south direction should be picked in each sidelap. As there is sidelap on both the east and west side of each strip, a total of approximately six tie points should be picked for each photograph. Each of these points will appear on six different photographs, so care must be taken to choose some marking that may be easily identified on each of the six photographs. A shadow should never be chosen in picking these points as it will have a different location on the adjacent strip. Wherever possible, an attempt should be made to pick the intersection of two roads or a stream and road, a stream fork, a well defined rock formation, or a lone tree in a well defined group. Buildings should not be chosen as this will hamper later operations. The point is marked on the photograph by piercing with a fine needle and is circled in red ink. The circle is 3/16" in diameter and a medium weight line. A drop pen or bow pen should always be used.

If a ground control point falls in the sidelap, it should be used as a "tie point" and be accurately marked on all overlapping photographs.

Picking Additional Photo Control Points: First the center or principal point of the photograph must be located. This is done by drawing intersecting lines through the collimating marks which appear on the photograph. These marks will be in each corner or at the center of each side, depending on the type of camera used. The center is marked with a needle point and a 1/10 inch square, using black ink. As the point located in this manner is not a definite image point it is very difficult to positively identify this same point on the overlapping photographs. Therefore, two reference points are picked, which may be easily identified on all three overlapping photographs. These reference points should be a definite object or image and are picked as nearly equidistant on each side of the center point and as close to the center as possible. These points are circled in black ink using a 2/10" circle as are all other points added to the photograph. It is required that three points be approximately equally spaced on each side, east and west, of the center point, making at least six points which will fall in that portion of the 60% overlap common to three pictures. Then as many additional intermediate points are picked as is deemed necessary regardless of whether they will fall on three photographs or only on two. A point which may be picked on only one photograph within a strip is useless and should not be considered.

The type of country being controlled determines the number of points to be picked. Relatively flat or gently rolling terrain requires little control other than the six points within the 60% overlap. In picking all photo-control points it must be borne in mind that these points will establish the final position on the map of all information used from the photograph. Not only must topographic features be controlled but differences in elevation must also be controlled. A stereoscope should be used to aid in properly placing the control. A well controlled photograph should have points uniformly spaced along the crests of all ridges, along the bottoms of all valleys and on any other prominent natural or man-made features. It has been found that an average of 30 to 40 control points are necessary per photograph in mountainous country.

Numbering Photo Control Points: Where so many points are picked it is necessary that each point have a number in order to avoid confusion. In the adopted system the number is divided into two parts. The first part is the strip number and the last part is the point number. The two parts are separated by a dash. Thus 16-42 will designate point number 42 in strip number 16. The strip numbers, of course, were determined when the areas were laid out for flying. The point numbers run consecutively, each quadrangle having its own set of numbers, starting at the top or north end of the strip, from left to right through the center of the photograph and continue from right to left through the intermediate points

between the centers. All ground control points will carry their own number or names as given by the Field Engineer and will be independent of the regular numbering system. This also applies to section corners or boundary monuments which may be identified on the photographs. All points including the "tie points" are numbered or named in black or red ink respectively on the face of the photograph except the centers and reference points which have no numbers. This should be done neatly and legibly, and using figures approximately 1/10 of an inch high.

Preparing Templets: In this process a templet is a sheet of transparent plasticele about the same size as the photograph for which it is used and containing radial lines to each of the control points. The templet is prepared by fastening it to the photograph with scotch tape to avoid slipping. The photograph and templet are then fastened to a drawing board or table by means of a needle through the center point. Using this needle as a pivot for the triangle, radial lines are drawn to every point that has been picked on the photograph. The lines are extended beyond point a little more than half the distance between the point and the center. The reference points on each side of the center are pierced in the templet.

Lines to points circled in black are drawn with black ink and those to "tie points," circled in red, are drawn with red ink. The draftsman must use a well sharpened ruling pen as the lines must be very fine, remembering that ink has a slight tendency to run or spread on the very smooth surface presented by the plasticele. There is a templet for each photograph and each templet must

bear the number corresponding to the photograph. This number is always placed in the northeast corner of the templet. The individual lines are numbered to correspond to the points to which they radiate. The number is placed along the line at about the position of the point on the photograph. These numbers are red or black to correspond to the lines they represent. Care should be exercised to avoid any confusion in placing these numbers. Serious error and loss of time with be avoided if numbers are clear and legible and when no doubt exists as to which line the number belongs.

Laying Photo Triangulation or Radial Line Control: Photo triangulation is a system whereby a series of points located on a set of properly overlapping vertical aerial photographs are, by means of radial lines intersecting according to certain established basic principles, brought into a definite scale position in a common horizontal plane. This operation is one of the most important phases of the work as it is this process which establishes the location and orientation of all detail shown on the map. The man doing this phase of the work must not be nervous and must have great pateience. He should have a keen analytical mind and be capable of exercising good judgment.

Preparing Projection and Control: For this operation special tables have been built of sufficient size to accomodate a thirty-minute quadrangle at a scale of 1:31,680. These tables are covered with a sheet of zinc. Zinc is used because

it has a low coefficient of expansion and also the metal presents a surface which can be continually reused over a long period of years. A polyconic projection is then plotted on the zinc surface. This is done by a capable and experienced draftsman and is duly checked to conform to our standards of accuracy. The draftsman is then furnished the latitude and longitude of all ground control points lying within the desired area. These locations are carefully plotted and checked. They are inked with a colored ink using a 1/4" circle and with cross lines drawn through the center of the circle. All points are numbered an named. Colored ink is used rather than black because it ahheres more readily to the surface of the zinc. All lines and lettering can be removed with an ammonia solution.

Assembling Templets: Before the operator begins to assemble the templets he studies the triangulation net and decides on the most advantageous portion of the area to start assembling. This will be the portion having the most and strongest control on one strip of photographs. It is also helpful if the initial strip laid is somewhere near the center of the quadrangle. The actual start is made if possible where two or more ground control points occur on two consecutive templets. These templets are then placed one over the other in such a manner as to bring the respective centers into alignment with each other. The two lines representing each control point will then be found to intersect. By moving the centers closer together or farther apart a relation will be reached whereby the intersecting control lines will fall exactly on the plotted locations. In this position the two

templets are fastened together with scotch tape and also fastened to the surface of the table. A definite scale and also a definite direction or orientation has now been established. As certain points have been purposely picked which occur on three successive templets it is now possible to add the third templet. It is added by holding the centers in true azimuth and moving the centers closer together or farther apart until the proper lines are brought into intersection with the intersections already established by the two previous templets. This process of adding templets may then be continued throughout the strip using two small strips of scotch tape to fasten each templet to the previous one. If the work is done with meticulous care the strip should maintain its proper scale and direction throughthroughout its length. However, small errors will creep in, usually due to the fact that all photographs are not made with the camera perfectly level. Therefore, the appearance of ground control points at regular intervals serves as a check factor to keep the strip constantly in proper scale and orientation.

When the initial strip has been adjusted to the satisfaction of the operator he fastens it securely to the table with scotch tape and then proceeds to assemble one of the adjacent strips. This is done in the same manner, only now in addition to the ground control there are also the many tie points which must be intersected as the strip progresses.

The reason for making red lines to the "tie points" is now clear as the intersection of the red lines can be easily and rapidly located in tying on an adjacent strip. The assembly continues strip by strip until the entire area is covered. The operator then carefully checks the entire layout to make sure that all ground control points and all ties have been properly intersected.

Transferring Points: In order to transfer points to the planimetric sheet the operator must begin with the uppermost strip and carefully circle the intersections of the minute lines so that the strip may be placed in exactly the same position on the planimetric sheet. The strip is then lifted in one piece and fastened in its proper position on the planimetric sheet by means of scotch tape. Then, using a sharp needle point, he pierces all picture centers and intersections within the coverage area. This should be carefully done to avoid making large holes in the planimetric sheet. After the strip has been pierced each point is circled and given its proper number or name, the photograph centers are enclosed in a small square and bear the number of the picture. This is all done free hand with a 2-H pencil. The circles are approximately 1/10" in diameter and the figures about 1/10" high. This process is repeated for each successive strip until the entire quadrangle has been transferred.

This will complete the procedure of establishing control and the base is ready for the transfer of all detail.

Control Tracing: Before any detail is added to the planimetric sheet, a control tracing must be made. This duty will be given to a draftsman, who makes a tracing on linen. This tracing carries its proper name and number in the lower right hand corner. These are made with a No. 350 Le Roy Guide, using a #4 pen. Latitude and longitude are marked at 2-1/2 minute intervals. All minute line intersections are shown by a 1" cross line. Points are marked with a 1/16" circle using a drop or bow pen. Figures and names are put on free hand about 1/16" high and must be neat and legible and placed horizontal to the bottom of the sheet. This tracing is the only record of the photo-control and is carefully preserved for future use or reference.

DETAILING PHOTOGRAPHS

This set of prints will be designated as the "Detail" set and will be identical in every respect to that of the "Control" set to be used in the preparation of a planimetric map and will be utilized for detailing only.

Due to the fact that all photographs must have 60% overlap it will not be necessary to detail every photograph, but the detail will be added only on alternate prints. However, the intermittent prints will be used for stereoscopic vision. In order to facilitate coordination between detailing Grazing, Timber, and Checking, the even numbered photographs should be used for detailing.

The detailing of photographs is the process whereby the cartographer interprets on the picture surface in the

form of a line drawing what the camera has recorded. The cartographer or draftsman working on detailing must be able to see stereoscopically. Unless he is able to do so, his services are useless. He must be conscientious and a fair draftsman and have a thorough knowledge of interpreting aerial photographs. In detailing photographs, the cartographer must adhere to the following instructions in the order of their priority.

Transferring Tie Points: Using only the photographs having even numbers all tie points and ground control points are transferred from the control prints. The locations are pierced with a fine needle and circled in red ink in the same manner as was done on the control prints. No figures are put on the photographs at present. The area enclosed by these points is bounded by a red pencil line thus establishing the coverage area. This is the portion of the photograph that will actually be used and as these tie points are common to adjacent strips there will be no duplication of coverage. It is then the duty of a draftsman to delineate on this area in black ink, all information contained on the photograph. Detail should be extended about 2/10" beyond coverage area to eliminate any possibility of a small gap between pictures. The photograph must be studied very carefully as an individual picture with and without the aid of a stereoscope.

Drainage: The drainage appearing on a photograph constitutes the most basic and permanent information. Therefore, all drainage should be carefully and faithfully delineated. Care should be taken to preserve all the character of each individual drain. Drainage should be first penciled with the aid of the stereoscope. Much drainage is apparent only by using the stereo-

scope and could not be put in any other way. Streams of 1/20" or more should be shown with a double line, treating each bank of the stream individually. Where a sand wash is evident the main channel of the stream should be shown if at all possible and the sand area should be shown with the sand symbol.

Bridges: It will be possible to distinguish only large bridges on the photograph. In these cases the abutments should be inked exactly as they appear. Smaller bridges and culverts will be located by the Field Inspector.

Flumes and Pipe Lines: Flumes will be shown in the same manner as ditches. Where pipe lines are discernible they will be shown in a continuous line and labeled "pipe line."

Tunnels: The portals of all visible tunnels should be inked together with the word "tunnel."

Corrals: No attempt will be made to detail corrals as these will be spotted by the Field Inspector. Corrals are shown on the finished map by a symbol so it is not necessary to detail the size and shape.

Airports: The boundaries of airports should be inked where visable. Where improved runways are visible they should be detailed. The word "Airport" should appear on the photograph.

Sand Dunes: Sand dune areas should be outlined and marked with the words "sand dunes." The detailer should not attempt to use the sand symbol in large areas.

Fire Lines: Where definite fire breaks are visible on the photographs, they should be shown. Each side of the cut over area should be detailed and the words "Fire Line" should appear on the photograph.

Lakes and Reservoirs: Lakes are outlined at the high water line and marked "Lake" on the photograph. If there is no evidence of water in the lake, the high water line will still be shown and the lake classed as "Intermittent." Reservoirs will be treated the same as natural lakes but the dam and spillway will also be shown.

Ditches: Ditches of a mile or more in length must be shown by the detailer. However, small laterals and, in general, ditches under one mile in length may be omitted.

Roads and Trails: The detailer will ink all roads and trails that he can definitely identify on the photograph. Main roads are shown in a dashed line, approximately 1/4" in length. All other roads or trails are shown by a very short dashed line. Care must be taken not to lose the characteristic features of a road alignment by careless workmanship. Portions of roads which are straight should be drawn with a ruling pen and straight edge and not free hand. No attempt should be made to "fill in" portions of roads or trails not clearly visible on the photograph. This will be taken care of by the Field Inspector who can do a more accurate job by actual ground comparison.

Railroads: Railroads are shown in a continuous line using the conventional symbol. All railroads should be detailed even if the detailer has reason to believe they are abandoned. It will be the duty of the Field Inspector to determine whether or not the railroad is in existence. The detailer will use a ruling pen and straight edge on all railroad tangents.

Buildings: The detailer will not always be able to find all buildings on the photograph. However, the photograph should be carefully studied and all visible buildings detailed. It is a common mistake for the beginner to show haystacks and similar objects as buildings, but with more experience it is usually possible to distinguish buildings from other objects.

Where a town or city of considerable size is encountered, it is not always practical to attempt delineation on so small a scale. We therefore enlarge the one or more photographs covering the town to a size which may be easily and accurately inked. Detailing of these enlargements is done with a ruling pen and straight edge. Streets are shown in a double line to their actual width. All buildings are inked in their true size and shape and all railroad yards, round houses, factories, tanks, etc., are inked just as they appear on the photo enlargement. All inking is done in a medium weight line, not so heavy as to obscure minute detail or character and not so light as to be difficult to follow.

Fences: Fences, while they are not shown on the finished map map, are very important in constructing the land lines. Therefore, all fence lines which appear to be a part of the land net should be shown. It is not necessary to detail fences of small, irregular tracts that will be of no help in adding the section lines.

Proof-Reading: The set of detailed prints must be proof-read by a man having wide experience in reading aerial photographs, and this must never be the same draftsman or cartographer who did the original work. He determines whether or not the detailer has completely and accurately performed his duties. He also checks to determine that all photographs are accurately matched, both within the strip and along the adjacent strip. Minor additions or changes will be made by the proof-reader. Major corrections will be referred back to the detailer.

Adding Control: The set of detailed photographs is compared with the control prints, and all photo-control points within the coverage area are added. As the tie points in red are already on, the additional points will all be in black ink, using the same size and weight of circle used on the control prints. All points must be named or numbered in black ink. The figures should be 15/100" high and should be so placed that none of the detailing is obscured. The number of each detailed photograph in the upper right hand corner is then given a thin covering of transparent lacquer and all photographs that have been detailed will be sent to the photo-lab to be bleached.

Machine Transfer

The cartographer assigned to this phase of the work will be furnished the detail set of photographs and each photograph having been detailed will be bleached - this being merely a black and white drawing of the cartographer's version of what the camera recorded of all information necessary to the planimetric map. In addition to this set he will be furnished the planimetric base sheet with all ground control and radial line control points established. It then becomes his duty to transfer the information recorded on the detail prints to the established control on the base sheet, thereby forming a pencil copy of the planimetric map. For this purpose a specially constructed machine has been built and this operation is known as the "Machine Transfer." The operator should have considerable experience in the compilation of maps and if possible some experience in Topographic Engineering; he must be very conscientious and neat in his work and, above all, have a thorough understanding of maps and the principles for making an accurate map.

The transfer machine consists of a lamp house adjustably mounted over a table and is operated by six controls, three located on the table and three on the lamphouse. The hand wheel on the left side of table moves the lamp house back and forth; the hand wheel on the right side moves the lamphouse sideways; and the small switch under the left hand wheel lowers the lamp house by turning left and raises it by

turning right. The crank control on the front of the lamp house revolves the picture and the vertical crank and large horizontal screw control at the rear are used for raising and lowering the bellows. Immediately under the horizontal screw is a similar, but smaller screw which serves as a brake to hold the former control in its set position. The switches for the lights and the fan are on the lower right hand side of the lamphouse. In order to dissipate the heat of the two 250-watt bulbs, the fan must be kept running when the machine is being operated, and left running if lights are shut off momentarily.

Pictures are placed with the face against the glass in holder on front of the lamphouse. Points on the picture are brought into relative position to those on quadrangle sheet, using the center point as a guide. Quadrangle sheets are machined by strips which run in north and south direction. As a matter of convenience, the half of the sheet nearest the operator is completed first and then turned around to complete the other half. When this is done, it will necessitate changing the position of the picture in the lamphouse.

When photograph is properly oriented, the following procedure should be follows: In order to reduce a picture, lower the bellows and raise the light box and in conjunction use other controls to manipulate points into position. As many points as possible, enclosing a given area, should be brought into coincidence before pencil work is started. Should rough country be encountered where only two points can be brought into position, the main drainage should be put in first,

making sure to use successive points on said drainage and, at the same time, marking where minor drainage enters, railroad crossings, fences, roads, trails, etc. and later adjusting between these marked points and other control points on or near same features. Extreme care must be taken to accurately copy all character in streams, trails, etc., and curves, tangents, and forks in roads should be accurately and clearly noted.

Where drainage originates at or near a controlled ridge, the starting point of each drain should be marked by adjusting to each two successive points on said ridge, and then adjusting each drain to its outlet in main drainage. Avoid the adjustment between separated ridges such as those that lie on opposite sides of a drain or other features.

All detail appearing on the photograph should be transferred and care taken that all detail ties into adjacent prints.

Label any detail which might be confusing, such as a spring or small lake which might be taken for a picture point.

After picture is finished compare it with penciled work to pick up any features that have been omitted.

Proof-Reading: Proofing must be done by a draftsman or cartographer who has a thorough knowledge of map compilation. This work must never by done by the machine man who transferred the original work. This procedure should follow as soon as possible after the machine transfer has been completed so that the operator who detailed the original transfer

work may make the corrections while the original work is still fresh in his mind.

The proof-reading is performed by comparing the detail photographs with the map for the purpose of determining whether all detail has been transferred and that the pencil copy is clear and legible. Particular care must be taken to see that no detail has been lost in the transfer.

Compilation of Land Lines

The compilation of land lines for planimetric maps is a highly skillful job and must be performed by a cartographer who is thoroughly experienced in this class of work. He should bear in mind that the land net is the weakest part of the planimetric map and in no case should detail be moved to fit a land grid unless a thorough investigation of the case has been made with the man laying templets and the man doing the machine work to determine whether or not an error has been made. The cartographer should bear in mind at all times that the land grid is a floating land net insofar as the accuracy of the map is concerned and is tied only to position where found corners are made.

The land lines must be added to the penciled copy of the planimetric map as correctly as possible from information on hand in the office. By compiling land lines on this copy the cartographer is able to determine where the weak parts of the land net exist, therefore determining to what extent the field inspector should search for additional information. Corners which have been located as part of the triangulation net will have been inked on the sheet and must be adhered to as well as

those located by photo triangulation. These corners will serve as a nucleus for the compiling of the land net. The General Land Office township plats will be referred to for courses and distances. It might be well to state here that the General Land Office surveys made prior to 1910 are not reliable, as in most cases they were contract surveys and a great many fraudulent. In cases where corner locations on the sheet do not agree with recent surveys or resurveys, a note should be made to have the Field Inspector check the corner in question. By using what found corners we have in conjunction with the General Land Office township plats, we are able to compile a good percentage of the land lines. Additional lines are projected from the information already determined.

The cartographer must watch carefully to see that section lines fit the self-evident features on the map. Fences and roads are often very good clues in locating land lines and these should be used judiciously. Lines made by the cartographer should be very light so that they may be easily changed if necessary, since this is a preliminary layout and may change to conform to the findings of the Field Inspector.

A photostat copy of the planimetric map to the same scale is made on 14x18" sheets which are mounted on cloth. Sixteen sheets are required for a full quadrangle - eight of these for a half quadrangle - and are mounted and disected on a single piece of cloth, folded and placed in a stiff

backed binder. However, before they are sent to the field inspector, the township lines are ruled in green ink and circles are placed at all points where the compiler wants additional corners found.

Adding Field Corrections

When the field inspector has completed his work, the control photographs and the photostat copy of the planimetric map are returned to the compilation department. The photostat copy will show all classifications and names while the photographs will have marked in red ink any additions or corrections accurately placed. This information has been put on the control photographs corresponding to the ones detailed. It is now necessary to transfer these corrections and additions to the bleached photographs. This is done by placing the corrected photograph over the bleached photograph and piercing through with a needle point all information to be transferred. This information is then inked on the bleached print in red ink and then added to the map by using the transfer machine in the same manner as the original information was transferred. The sheet is now given a final check to be sure all field additions and corrections have been added. When this check is completed the map will be in final form so that the draftsman inking the sheet will need no information other than the classification sheet turned in by the Field Inspector.

S E C T I O N K

FIELD INSPECTION OF PLANIMETRIC MAPS

General

The field inspection of planimetric maps will be performed by a field engineer (who is Chief-of-Party) and one or more assistants. This phase of planimetric mapping is of the utmost importance and should be given extreme care by the Chief-of-Party for it is his responsibility to make the last and final analysis of the composite map in its pencil form before it is given to the draftsmen for final inking.

Field inspection consists of the actual checking in the field (by observation and comparison) of all data outlined from aerial photographs in the construction of a planimetric map, the running of ground surveys at pre-determined intervals for checking accuracy of office work, classification of all culture, checking all boundary lines, locating additional section corners, checking and adding all nomenclature, connecting in the field all detail that was obscured from the photographs and left hanging loose. In general, making a final and complete check of the planimetric map before it is ready for publication.

Chief-of-Party

He must be an engineer with considerable experience in map compilation, having a thorough working knowledge of methods obtained in the construction of a planimetric map, the faculty of contacting local residents and securing information, and he must be alert and energetic.

Assistant

The assistant will be an Engineering Aid and will assist the Chief-of-Party in performing all his duties; he must be able to drive an automobile, assist in pack trips, have some knowledge of the methods of constructing planimetric maps from aerial photographs, and he must be energetic, conscientious, and interested in his work.

Equipment

The party will be equipped with a suitable automobile, preferably of the panel-body type, and with sufficient gas capacity to enable long trips between filling stations. Also the following equipment will be furnished:

1 Scale - 2" - 1 Mile
2 Canteens - 1 gal. type
1 Water Bag - 5 gal.
1 Alidade - Telescope - 18"
1 Plane Table Board - 18x24"
1 Tripod - Johnson Head
1 Rod - Stadia
1 Compass - Forest Service Standard
1 Tape - Steel - 100 Ft.
1 Stereoscope - Folding Type

On quadrangles where pack trips will have to be made, the necessary camping equipment will be furnished. The rental of pack horses will be taken care of by the Chief-of-Party.

Supplies

The Chief-of-Party will be furnished a photostat copy, mounted and disected for convenience, of the original planimetric map in its pencil form on the scale of 2" = 1 mile; a complete set of photographs covering the quadrangle with stereoscopic coverage; a list of all

U. S. Geological Survey and U. S. Coast & Geodetic Survey bench marks; and all necessary stationery and stationery cabinet or field chest. He will also be furnished with a set of all existing up to date maps of the country to be covered.

Approach to Work

The field party will be organized in the office in Denver. The Chief-of-Party should report to the Forest Supervisor on whose Forest he is going to work before undertaking any field operations. He should secure from the Supervisor and Rangers all information possible regarding nomenclature and secure a map showing all main Forest Service trails and stock drives with their names, the location of all Ranger Stations, both temporary and permanent, and make arrangements to secure the assistance of a Ranger in locating additional section corners. In short, take advantage of the knowledge of the Supervisor and Rangers of their Forest in assisting in any possible way with the work. After this information has been secured from the Supervisor or Rangers, the Chief-of-Party will proceed with his work in any manner he sees fit, bearing in mind the following instructions:

The photostat copy of the quadrangle is to be used only for classification, identification of photographs where corrections and additions have been made, and for nomenclature. In no case should this photostat copy be used to show the location of any amount of detail or be relied upon for the correct position of any material shown in its respect to the true position of the map. All correc-

tions, regardless of how large or small, must be indicated on the aerial photographs in red and noted on the photostat copy of map, giving the photograph number where corrections occur.

When detail appears on the photostat map that should be eliminated from the final map, the word "Omit" should be written on the photostat copy over the detail to be omitted.

Roads and Trails

In the classification of Roads and Trails, they will be classified on the final map in four general classifications; namely, State and Federal Highways, Main and Good Motor Roads, Poor Motor Roads, and Trails. This classification is made entirely by the field inspector. As far as he is concerned the only difference between a State or Federal Highway and a Main or Good Motor Road is that he will show both on the classification sheet in a solid red line, but in the case of State and Federal Highways he will show the number of each, paying particular attention to junctions and their route through congested areas. Poor Motor Roads will be marked with a red, dashed line. Trails will be marked with a red, dotted line and the word "Trail" labeled along side.

There will be a great many cases in the compilation of the map where the cartographer has shown a maze of roads or turn-outs. Care should be taken in picking the correct road to be shown on the final map and marking all others "Omit." For the information of the Chief-of-Party, a State or Federal Highway is any highway set up on the State and Federal Systems and numbered. A main or good motor road is determined by any road which is occasionally main-

tained by grade and blader, either public or private. A second class road is any road which can be traveled by car and is not maintained or bladed. A trail is any passage or way that is occasionally cleared permitting travel by horse or foot and has a definite origin and destination.

Bridges, Trestles, & Culverts

These must be shown by either symbol or exact measurement to scale. Any bridge over 300 feet in length must be shown to scale. This may be done by locating the abutments on the photograph. Bridges less than 300 feet may be shown by the usual bridge symbol at the intersection of stream, road, or railroad. In determining where a bridge stops and a culvert begins, show a bridge symbol for any structure that necessitates the breaking of the road grade. Where streams pass under road grade irrespective of whether or not large or small conduit, wooden, concrete, or metal, culvert symbol should be shown on each side of road. All symbols of bridges and culverts of less than 300 feet in length will be shown on the classification sheet only. All bridges over 300 feet in length, abutments must be shown on the photograph if not determined in the compilation of map. The inspector should bear in mind that if he should not show a culvert or bridge symbol where streams cross roads or railroads, these will be treated as fords and will be shown as such on the finished map.

Railroads

All railroads, round houses, wyes, sidings, and spur lines must be shown and name of railroad on nomenclature plate; however,

no attempt should be made to show abandoned railroads. What is meant by an abandoned railroad is any line or spur on which steel has been taken up or is in the process of being taken up. If the steel remains on the ground, regardless of whether or not trains are operating on it at the time the inspection is made it should be shown as a railroad. Railroad tunnels will be shown by the usual symbol, but located on the photographs. If tunnel carries a name, it should be shown on the nomenclature plate. No classification will be made between standard and narrow gauge tracks, nor will any attempt be made to designate single and double tracks.

Telephone, Telegraph & Transmission Lines

These will be shown by the regulation symbol, indicating on the photostat copy only their existance with a reference to the photograph number, but they must be shown on the photograph in their correct position in respect to side of road or general direction of line. In locating these lines on the photograph, no attempt should be made to classify or to include the number of lines if one or more lines run down the same side of the road. This should be taken care of with symbol only and no account should be made of short spur lines leaving the main line for a distance of one mile or less; however, lines leaving the main line for a distance of more than one mile should be shown. When a spur line or a main line goes across country through timbered or flat, prairie country and where detail makes it almost impossible to locate the exact position of this line without a survey, these lines may be indicated on the photograph in their general position, but this should be so stated on the photograph for future reference.

Telegraph lines are not so plentiful, but they should be treated in the same manner as telephone lines. These lines in most cases will run parallel to railroads or roads. Care should be taken in distinguishing between telephone and telegraph lines.

Transmission lines - No attempt should be made to show small power lines running at random through the country. The only lines it is necessary to indicate are the high voltage lines running parallel to railroads, roads, or through rights of way. The location of these lines should be treated in the same manner as telephone lines.

In practically every case of cross country telephone lines, the inspector will find some telegraph wires running on same poles. These telegraph wires are reserved for the owner's use and should be classed as telephone lines only. In making the distinction between telephone and telegraph lines the following rule should be adhered to: If a line is owned and operated by a local telephone company, Mountain State or Bell Telephone, it should be classed as a telephone line; if owned and operated by Postal Telegraph or Western Union or a railroad, it should be classed as a telegraph line. The inspector will find this distinction easy to make simply by watching the markers along the poles as to their ownership. In some rare cases a telephone company will lease the right of way over a telephone line to a telegraph company and in this case both symbols should be shown.

Drainage

Water courses will generally be shown by four different symbols: Large Rivers, Streams, Intermittent Streams, and Ditches or Canals. Large Rivers will be considered as any river with sufficient width to enable its width to be shown by two parallel lines, the scale of map governing this entirely. A stream is any stream flowing water the major portion of the year. An intermittent stream is a stream which only flows water during the wet season. A ditch or canal is a man-made course for water.

In classifying these water ways, on large rivers each meandering bank should be treated separately in its true course. This, however, should be taken care of by the map compilers and should give the field inspector no concern except to check and see that this has been done.

Streams and Intermittent Streams must be classified on the classification sheet. In order to eliminate work and cluttering of the classification sheet, all streams have been shown on the pencil copy in solid line. The inspector must classify all streams with blue pencil omitting any classification of intermittent streams. By so doing this will mean all streams on the classification sheet not classified become intermittent streams when the final drafting is done. Therefore, extreme care should be taken in the classification of streams which carry water. In doing this, the inspector will find that the Ranger's knowledge of his forest will be of considerable help; also should timber or grazing surveys

be working the country simultaneously or have already worked it previously, their judgment as to the classification of these streams should be accepted.

Ditches and canals must be shown on the classification sheet in a solid blue line with the word "Ditch". Any location necessary must be shown on the photographs. No attempt should be made to show all small laterals or small, individual irrigation ditches. The inspector should confine ditches and canals to those being well constructed and generally considered the main lines. In each case, the head gates must be found and located on the photograph according to symbol.

All flumes and siphons must be shown. These may be shown on the classification sheet by their symbol and name, but the exact location must be shown on the photograph.

Since the majority of detail on planimetric maps in this particular Region will be drainage, it is not necessary for the field inspector to make any attempt to make the exact location of this drainage; however, he should make a thorough comparison between the photograph and the cartographer's version of the stream making sure that the meandering courses and detail are correctly shown. In case an error of this type is found, mark a circle around the stream with a note to re-detail.

Lakes

These may be defined in two general classes: lakes, reservoirs, or ponds; and intermittent lakes, reservoirs, and ponds. The word "lake" or "intermittent lake" will serve to classify them on

the classification sheet. However, should the inspector encounter a lake which at various seasons is practically dry, he should outline on the photograph the water line and also the intermittent lake line thus enabling the draftsman to show the high and low water of this lake. This can be done by field comparison of the photographs with the ground. In the case of lakes and reservoirs where the water has been diverted either around or leaves from an outlet other than the normal spillway, this should be shown by the ditch or flume symbol whichever the case may be. In all cases the information must be shown on the photograph. In places where the dam has been broken and the majority of the structure is left standing, lake or reservoir should be shown as intermittent.

The inspector should bear in mind that he can only show such features as the scale will permit. Where there are bodies of water of one acre or less, no attempt should be made to show them.

Springs

Springs should be shown by their usual symbol, but no particular search should be made to locate these springs; only show those that are found in the natural course of the work or that have been called to attention by previous maps. Here again, if the grazing survey has preceeded the field inspection they will have located all springs within the area. In this case they should be transferred to the inspector's set of photographs so they will be shown on the final map.

The word "Spring" or "SPR" will be shown on the classification sheet, but the exact location must be shown on the photograph.

Falls and Rapids

No attempt will be made to show falls and rapids other than those of prominence or those having been named and located on previous maps. Should any occur of this nature they should be shown on the photograph by symbol and the name on the identification sheet.

Dams

In all cases where dams are of sufficient width and length that the scale will permit their being shown on the map in relation to their exact size and shape, this should be done using the photograph for the exact information. Where dams are small they may be shown by the dam symbol, but this should be done on the photograph only, using the classification sheet to show the name and kind of structure. However, no account should be made of small check dams, beaver dams, or other small structures obstructing the flow of a stream. Should the inspector encounter a dam that has been broken, but where the majority of the structure still stands he should show it as though no break occurred.

Glaciers

Glaciers will be shown by outlining on the photograph the boundary and marking "Glacier." Its name should also occur on the identification sheet.

Washes

In streams and rivers which have wide sand beds, symbols must be used. Since this feature is obvious on the photograph, it is very doubtful that they will be overlooked; however, they should be checked and if they have been overlooked the classification sheet should show

a small arrow to stream stating "See Photograph Number _____ for Sand."

Topography

Inasmuch as the planimetric maps do not portray the earth's surface in relief, there is very little or no topography to be shown; however, we do indicate by hatchures outstanding mountain peaks and ranges and series of cliffs and bluffs which are natural barriers when attempting to cross country. While checking for miscellaneous detail, it is well to bear in mind that should a high, outstanding peak not be indicated on the map, it should be marked on the classification sheet and shown in form lines on the photograph. This should be applied in all cases to peaks having names.

Bluffs and cliffs if omitted from the planimetric map should be indicated on the classification sheet and a straight line with bluff symbol on the photograph. However, this only applies to outstanding cliffs or rim rocks and no great amount of detail should be gone into regarding this feature.

Sand Dunes

Sand dunes should be outlined on the photograph just showing the boundary, which in all cases will be obvious; however, a note must be made on the classification sheet referring to the photograph number.

Boundaries

A finished planimetric map will show all boundary lines such as National Forest, Inter-forest, National or State Lines, County Lines, City Corporate Limits, Reservation Lines, and Land Grant Lines.

In this Region the majority of these lines follow township and section lines or sub-divisional lines and they will be of very little or no concern to the field inspector as they will be added to the map when making final drafting; however, they should all be checked by the inspector to see they do follow land sub-divisions and in cases where such lines do leave the land sub-divisions and follow mountain ranges, as is quite often the case of county and Inter-forest boundary lines, these lines should be indicated on the classification sheet and added to the photograph. This should only be done by using the photograph stereoscopically, tracing line along the high point of the divide or range whichever the case may be.

An inquiry must be made by the inspector into each town and village as to whether or not it is incorporated, and if it is the corporate limits must be shown. Here again, if these corporate limits follow land lines or sub-divisions they may be so noted on the classification sheet, but should they be of a regular nature they must be treated as a map correction, adding the exact boundary on the photograph.

Section Corners & Lines

Inasmuch as the triangulation party has previously worked over this same country as the field inspector and has found a great number of corners and these corners being indicated on the pencil sheet by the found corner symbol from these previous found corners, the office has made an attempt to compile the land office grid but will have encountered some difficulty in the lack of information of estab-

lished found corners. The map compilers will note on the pencil copy of the planimetric map where they wish additional information in the form of found corners. In addition to these corners requested, the inspector should consult the Forest Ranger and locate as many corners as possible without undue cost or handicapping his work for it, bearing in mind that the more corners located the stronger the township net will be. These corners should be indicated merely by symbol on the classification sheet giving the photograph number and locating exactly on the photograph. However, if corner falls in densely wooded territory or out in open fields where it is impossible to locate the exact position of this corner on the photograph by comparison to detail, the inspector must pick some known tree, cross trail, or some definite object on the photograph, giving the true position on the photograph and marking on the reverse side the compass bearing and the number of feet to the found corner. This is shown in Figure 1.

The location of township lines and section lines are of no concern to the field inspector as they will be compiled from found corners only.

Monuments, Bench Marks, and Triangulation Stations

Boundary monuments, first, second, and third order triangulation stations, as well as all Forest Service fourth order stations, bench marks, and U. S. Location and Mineral Monuments will be shown on the original sheet. Inasmuch as all of these monuments, outside of bench marks, have their positions established by latitude and longitude they are of no concern to the field inspector, but bench

marks along level lines which do not have their positions established must be shown. The inspector must obtain all of these from the Survey and Maps Office before he goes to the field. As these lines generally follow railroads and main roads, it will be necessary for him to pick up one bench mark as a starting point and follow the line description across the project, indicating on his classification sheet the bench mark, permanent or temporary, and its elevation, but marking the exact location of the bench mark on the photograph. Extreme care must be used to find as many of these bench marks as possible.

Buildings

All buildings must be shown. No attempt should be made to show these buildings on the classification sheet; merely draw a circle in their proper position and give the photograph number. Then on the photograph, locate each individual building by piercing a pinhole through the photograph and recording on the reverse side. Particular care must be taken in regard to school houses and churches--in all cases giving their names and numbers. No attempt should be made to show every outhouse in a cluster around ranches - only show the main buildings.

Ranger and Guard Stations must be noted and particular care should be taken where these stations fall in groups of buildings to show which building by its correct symbol is the Ranger or Guard Station. It will be necessary to deviate from this somewhat in cities or large towns. In the business districts where the blocks are solid or nearly so, they should be shown in solid blocks, but

in the residential districts where houses are congested, it is best to show each individual house; however, these will probably have to be made small in the final drafting. Extreme care should be taken where houses are set out of line; however, this can be accomplished by studying the photographs very carefully.

Mines

Inasmuch as this particular Region is literally covered with mines of various types, quarries and prospect holes, the inspector should pay no attention to prospects, small quarries, and old abandoned mines unless the old mine has buildings still standing, but all mines being worked must be shown - the name of the mine on the nomenclature plate and the location on the photograph.

Saw Mills

There are two general classes of saw mills - permanent and portable. No consideration should be given to portable saw mills, but all saw mills of a permanent nature must be shown - the symbol for saw mill to be shown on the identification sheet with the name and the location on the photograph.

Oil & Gas Wells

Oil and Gas wells must all be shown. If they are located in fields, the name of the field must be shown on the nomenclature plate, but the location of the well must be shown on the photograph. The inspector should not consider any abandoned wells as they are of no map value.

Fences

All fences that can be seen on the photograph and determined as such will be shown on the pencil copy of the planimetric map. These fence lines will only be used as a guide to help orient the land net and should be of no concern to the field inspector as fence lines will not appear on the final planimetric map.

Airway Beacons

There are generally five classes of these beacons: namely, Airway Light Beacons, Airway Light Beacons Flashing, Airway Light Beacons with Code Light, Land Mark Light Beacons with Bearing Projector, and Land Mark Light Beacons without Bearing Projector. Airway Beacons should not cause the inspector a great deal of work as these are secured before going to the field from an airways map showing all such beacons and their classification. With the guidance of this map he should locate on the photograph the position of each beacon and indicate on the classification sheet its classification.

Airports

All airports must be shown regardless of whether they are of a temporary or permanent nature. This may be shown by indicating the boundary on the photograph and if it is an improved airport the runways may be shown; otherwise, just the word "Airport" will distinguish it.

Nomenclature

The problem of adding nomenclature to the planimetric maps will involve considerable skill and care as this phase of the work is of the utmost importance and will involve the majority of the inspector's time. In approaching this problem the inspector will be confronted with a great many difficulties. For example, he will have all the existing maps covering the territory he is working, and names of a great many of the features have already been published. These names, if not in error, take preference over all others However, due to the density and the tremendous amount of detail the planimetric maps are built upon, there will be a great many cases where no names have been published on previous maps. Therefore, it will be necessary in all cases to add from 20 to 50% more names to the map than have ever previously been shown. In doing this extreme care must be taken and the inspector must be guided by the rules and regulations of the U. S. Board of Geographic Names.

In order to make more effective and uniform the naming of these features on planimetric maps, a form has been prepared whereby the inspector must fill in this information for each and every name to to shown on the nomenclature plate. As a guide in determining whether a name should be submitted to the board for decision or whether it may be used without such action, certain classes of names are defined below and are grouped into those which ought to be submitted, and those whose submission to the Board is invited but not required. It

is recognized that there are names which do not fall in any of these classifications and which should be judged individually. In such cases a safe, general rule is that any name which does not clearly fall into one of these classes that are grouped as usable without being submitted, should be submitted for decision. It will be the inspector's responsibility to indicate on the form filled in for each name his opinion as to whether it falls in Group A, B, or C. Group A covers names that should be submitted to the Board, Group B covers names that may be used without being submitted to the Board, and Group C covers names whose submission to the board is invited but not required.

Group A

1. All names for previously unnamed features.

2. New names for features that previously carried some other name.

3. Old names that are given essentially new applications.

4. Names that apparently should be spelled or applied at variance with existing decisions.

5. Names that apparently should be spelled or applied at variance with a "provisional adoption" by the former Board, as in the publications here cited (these publications pertain to Alaska and the Philippine Islands and the War Department and therefore will not be considered in this Region.)

6. Names whose unapproved previous usages in Government, State or private publications do not agree, either as among such published usages, or as between published usage and local custom.

7. Names of "places" (cities, towns, villages, and settlements) which are duplicated within the same state.

8. Names whose governmental spelling, as represented by a formal decision, or by "provisional adoption", or by the name of a post office, is at variance with dominant local usage or with a usage that is prescribed by law or by charter.

9. Names on which there are formal decisions, if the existing decision has not been ·ly followed after adequate trial.

10. Names on which there are formal decisions if the existing decision is objectionable to the State Board concerned.

11. Names used incidentally in Congressional legislation or used in any enactment by State or Territorial Legislature which do not fall in any of the classes defined under Group B.

12. Names of Cities, Towns, and Villages which are different from the post office or railroad station therein.

Group B

1. Names for which there are existing affirmative decisions.

2. Names indicated as the approved form in published lists of names "provisionally adopted."

3. Names that have been specifically adopted by naming enactment of Congress.

4. Names that have been formally approved by a State Geographic Board, in conformity with the rules of the U. S. Board of Geographic Names, insofar as they apply to features wholly within the jurisdiction of the State Board.

5. Official names of post offices, insofar as they apply only to the names of the post offices.

6. Names of civil divisions, as adopted by the Bureau of Census insofar as they apply only to the civil divisions themselves and not to other features, and insofar as they are not in conflict with names that are otherwise in general use.

7. Names that are in use on the latest issue of a U. S. Government map, published since 1920, and that after reasonable search appear not to be in conflict with other published usages, nor with local usage, and that conform to the standards adopted by the Board.

8. Names not strictly geographic, usually ephemeral, that are applied to other structures or features such as Park Headquarters, fish hatcheries, ranches, mines, etc.

9. Names in generally accepted use for such features as dams, railroads, highways, bridges, light houses, and other structures which have been officially applied by the organization, legal authority, or civil unit which controls the feature, insofar as the name applies to the structures and not to the neighboring or resulting features.

10. Names not at variance with any of the principles adopted by the Board and that are in undisputed local usage.

11. Names that are in good standing, but that do not agree with names that clearly were spelled or applied in error.

12. Names of minor features that are of navigational importance only, which are in well established local use, and which are unlikely to be used on maps other than charts, or in the Coast Pilots or Light Lists.

Group C

1. Names in undisputed local use which conform to the general practice of the Board in the consideration of old names, but which may not conform to all the rules which the Board would apply to new names.

2. Names of natural features as distinct from "places" (See A-7), which are likely to cause confusion through duplication.

3. Names on which there are existing decisions made in conformity with the general rule which the Board has modified.

4. Names on which there are existing decisions inconsistent with later decisions on related or similar names.

5. Names on which there are existing decisions but concerning which important new evidence has been brought forth which was not available or was not considered when the original decision was rendered.

6. Names on which there are existing decisions or names in undisputed use or that are objectional because they are awkward, misleading or difficult to spell or pronounce providing they are not so well established that it would be impracticable to try to change them.

PRINCIPLES RELATING TO GEOGRAPHIC NAMES

"Euphonious and suitable names of Indian, Spanish, or French origin should be retained.

"Names suggested by peculiarities of the topographic features designated - such as their form, vegetation, or animal life - are generally acceptable, but duplication of names, especially within one state, should be avoided. The names 'Elk,' 'Bald,' 'Beaver,' 'Cottonwood,' 'Mill,' 'Moose,' and 'Round' are altogether too numerous."

Names in honor of living persons are not approved.

"Long and clumsily constructed names and names composed of two or more words should be avoided. It is a foregone conclusion that such names will usually not be adopted by the public. If the name selected consists of more than one word, the words should be combined if practicable.

"The multiplication of names of different parts of the same feature, such as a river or mountain range, should be avoided. Only one name should be applied to a stream or mountain range throughout its entire length; in the case of a river the name should usually follow up its longest branch.

"The naming of forks, prongs, branches, etc. as 'East Fork' or 'North Prong' of a river, should be avoided unless there is a special reason for it. In most cases, independent names should be given to a river's branches.

"That spelling and pronunciation which is sanctioned by local usage should, in general, be accepted.

"Where names have been changed or corrupted, and such changes or corruptions have become established by local usage, it is not usually advisable to attempt to restore the original form.

"Where a choice is offered between two or more names for the same place or locality, all sanctioned by local usage, that which is most appropriate or euphonious should be adopted.

"The possessive form should be avoided whenever it can be done without destroying the euphony of the name or changing its descriptive application

"In names ending in 'burgh' the final 'h' should be dropped if possible.

"The word 'center', as part of a name, should be spelled as above and not 'centre,' unless local usage or legal documents require the latter.

"The use of hyphens in connecting parts of names should be discouraged.

"The letters 'C.H.' (courthouse) appended to the names of county seats should be omitted, if possible.

"It is desirable to avoid the use of the words 'city' and 'town' as parts of names."

"Form and Content of Decisions"

"The earlier decisions of the United States Geographic Board usually indicated only the spelling of a name on which a decision was rendered, followed by information sufficient for the identification of the place or feature to which the name applied. The range of problems presented to the Board has increased, however, and it has come to be realized that the information obtained by the Board, frequently through correspondence with persons locally acquainted with the history of the name, is of considerable value in itself. The published decisions of the Board are therefore amplified, when pertinent information is available, to include the following: (1) spelling, (2) thing named, (3) location, (4) pronunciation and hyphenation (when not self-evident), (5) rejected names and forms of names, and (6) history and derivation of the name."

The inspector should approach the naming of all features on the quadrangle by first taking the existing maps and transferring in pencil to the photostat copy or identification sheet all of these names, before going to the field. This will enable him to have all available material on the one map and he will not have to refer to various maps, thus eliminating considerable chance of error and overlooking some important name. He should then make inquiry from local residents as to the names now appearing on the sheet, also other features that such residents may know of that bear local names, and such features that in his opinion should carry names.

In establishing local usage, the inspector should never take the word of one individual, but should consult with at least two and preferably three before forming his opinion of the local use of any names to be used on the map. It will be the inspector's responsibility in filling out the form for each name to state on the form his opinion as to whether the name falls in Class A, B, or C.

These names will be reviewed before they are added to the final map and if, in the opinion of the Regional Office, any names must be submitted to the U. S. Board of Geographic Names, this will be taken care of by the Office of Surveys and Maps, and not by the Field Inspector. The inspector should arrange all the forms in alphebetical order in a book prepared for such purpose, so they may be easily referred to and compared during field operations as to the duplication of names.

The inspector should bear in mind at all times that he is not to add names promiscuously to any features unnamed, but to only obtain local names for such features. Should he encounter prominent topographic features not having names, they should be so noted on the form, so they may be considered for naming at a later date.

S E C T I O N L

FINAL DRAFTING

General

Inasmuch as the inking and lettering of planimetric maps is a highly specialized drafting procedure, they will always be given to a draftsman experienced and thoroughly trained in this type of work. The drafting will be under the constant supervision of the Chief Draftsman and it is his responsibility to see that the maps are inked and lettered according to approved map standards. The Chief Draftsman must keep a constant check on the work for quality, speed, and accuracy and will be required to make decisions on matters pertaining to all this work.

Procedures

The planimetric maps will be delivered to the Chief Draftsman in final pencil form. These maps will be accompanied by a classification sheet which will show the classification of all roads and streams, location of bridges, culverts, and nomenclature. The draftsman should bear in mind that this map in pencil form has been proof read in the field, checked, and corrections added; therefore, he should spend no time in questioning the amount of detail shown. The classification sheet will show the class of roads as to whether or not they are state or Federal Highways, first or second class roads, or trails, the classification of streams, as to whether or not they are streams or intermittent streams, the location of bridges and culverts, and the names of all features. Should the draftsman encounter something on the pencil form that is not quite clear to him he should keep a

set of notes, using the standard form (Notes on Map Work). This will eliminate undue interruption and all questions can then be decided upon at one time.

The draftsman will first ink the main drainages and letter them. He should then letter all other names and numbers and ink the section lines, roads and trails, intermittent streams, etc. The draftsman should follow the classification sheet at all times but in no case, other than those of bridges and culverts, should he rely on this sheet for the location of features on the planimetric map. He should bear in mind that this sheet is merely a classification sheet and that the Field Inspector has not located detail to any degree of accuracy on this sheet. The exception of bridges and culverts is due to the fact that these features are obvious on the planimetric map and therefore do not necessitate the exact location on the photograph or the pencil map.

The draftsman should keep that portion of the quadrangle sheet not being worked on covered at all times and refrain from leaving pieces of scotch tape or other substance stuck to the map. When inking of the sheet is completed, it should be thoroughly cleaned with art gum or a Dixon gem eraser. All ink work that has been dimmed from erasure must be retouched.

The draftsman who is employed in this work should concentrate on the following instructions:

Lettering & Nomenclature

Lettering: The draftsman shall follow Publication M-5192 (Forest Service Map Standards) for style of lettering. He shall not use shaded lettering. Simple one-stroke, free-hand lettering shall be used except in designated instances where Wrico or Le Roy mechanical lettering is substituted. The draftsman shall avoid, as far as practicable, reverse, sharp, or compound curves in lettering. He should strive to letter the name of creeks or rivers on graceful, continuous curves, so the eye can follow the name of this feature at a single glance. Spacing of letters should not be stretched, except on long ridges and divides. On large rivers the name should be lettered more than once if necessary. For all lettering the placement of names should be given careful consideration so that as little detail as possible is disturbed. Detail should not be inked through lettering. In shadow lettering, used for Forest names, the detail should stop on the imaginary outline. In the majority of cases these letters can be placed to miss the important detail. Since several draftsmen may, at various times, ink and letter planimetric maps, it is important that a certain standard be adhered to so that all maps will have a uniform appearance. The symbol chart should be referred to for these standards.

Nomenclature: The draftsman will find that all nomenclature has been added to the classification sheet in red ink. In no case will it be necessary for the drafts-

man to refer to other publications for the authority of a name as they will be clearly identified and checked by the map compilers before turning the map over to him.

Marginal Lettering: Road destinations, latitude and longitude, townships, and ranges will be inked directly on the 2" planimetric map sheet. All other marginal lettering will be compiled on separate sheets of bristol board with the LeRoy type of mechanical lettering. This data is turned over to the lithographer with the planimetric map and is reduced two to one, with the exception of the legend which is reduced as indicated.

GUIDE FOR MECHANICAL LETTERING

PLANIMETRIC SHEETS

LeRoy		Wrico		
Guide No.	Pen No.	Guide No.	Pen No.	Remarks
		500 - shadow	6	Forest Names (In small areas use #250 or #275 shadow lettering
120	00	120	7	Ridges, Mountain Ranges, and Divides
140	0	140	7	
175	0	175	7	
200	1	200	6	
140	0	140	7	County Names
140	1	-	-	Road destinations (marginal) (Slant Caps)
120	00	120	7	Latitude & Longitude Numbers (Marginal)
200	1	185	7	Guide Meridians & Std. Parallels (Upper & Lower Case)

LeRoy		Wrico		
Guide No.	Pen No.	Guide No.	Pen No.	Remarks
120	00	120	7	F.S. 4th Order Control Stations
140	0	140	7	Section Numbers
200	1	200	6	Township & Ranges
200	2	-	-	Name of Quadrangle
425	4			Number of Quadrangle (Does not appear on printed map)

MARGINAL LETTERING

LeRoy		Wrico		
Guide No.	Pen No.	Guide No.	Pen No.	Remarks
350	4	-	-	"U.S. Dept. of Agriculture, Forest Service"
200	2	-	-	Scale and Datum (Vertical-Upper & Lower Case)
200	2	-	-	Credit for control compilation, etc. (Vertical-Upper & Lower Case)
200	2	-	-	"Advance Sheet, Subject to correction" (Slant-Upper & Lower Case)
200	2	-	-	"Polyconic Projection 1927 North American Datum --- Principal Meridian" (Vertical-Upper & Lower Case)
140	1	-	-	Magnetic Declination
500	5	-	-	Name & No. of Quadrangle
290	4	-	-	Numbers of Adjacent Planimetric Sheets

LeRoy		Wrico		
Guide No.	Pen No.	Guide No.	Pen No.	Remarks
290	4	-	-	State and Forest Names
200	2	-	-	Legend (Body) - (Vertical- Upper & Lower Case)
240	4	-	-	Legend (Word)

CONTROL TRACING AND PHOTO-INDEX NUMBERS

LeRoy		
Guide No.	Pen.No.	Remarks
200	2	Latitude and Longitude Numbers
290	3	Name of Quadrangle
425C	4	Number of Quadrangle
140	0	Photo-index Numbers (printed on reverse side of published Sheet) - (Slant)

1-1/2" Standard Shield Forest Service Shield

Note: All mechanical lettering vertical caps unless otherwise specified.

Note: Symbols for the following features have been drawn to scale on the "Symbols Chart" and should be strictly adhered to for uniformity of all planimetric maps.

Roads

All State, Federal and first class roads will be shown by two continuous parallel lines with an outside width of 1/20

of an inch. A railroad pen must be used for this work, except on acute curves where the draftsman may use a lettering pen advantageously. Do not attempt to draw road alignments freehand. Use particular care on tangents and curves by using a triangle or curve as a guide.

State and Federal highways shall be indicated by their symbols filling in a strip 3/10" long and at 3/10" intervals. State and Federal highways shall carry their numbers according to the legend - the State highways being shown in a cirlce and the Federal highways being shown by a shield, the numbers only appearing in the circle or shield, indicating the number of highway.

If a bridge or culvert symbol is shown at a stream crossing, the road must be cleaned out. Should neither a bridge nor culvert symbol appear, the stream should be inked crossing the road, thus indicating a ford.

Secondary roads should be shown in the same manner as first-class roads, with the exception that they are to be shown by broken lines.

Trails may be drawn freehand and will be shown with a single broken line.

Bridges, Fords & Culverts

Any bridge of 300 feet or less will be shown by symbol only. These symbols, as shown on the classification sheet, indicate whether or not they are a bridge or culvert. No location will be given to the draftsman as to the position of these symbols as it is obvious they are to be placed where stream crosses the road or railroad regardless of whether

it is a first or second class road or trail. In all cases where a bridge or culvert symbol is not shown on the classification sheet the draftsman will continue the stream line across the road, trail, or railroad, automatically indicating the crossing to be a ford. Bridges over 300 feet will be inked in their true size and shape as penciled on the planimetric map.

Culverts will not be inked on planimetric maps, but will be on the classification sheet to distinguish whether or not a stream crosses a road, and for future information maintained in the office of Surveys and Maps.

Railroads

All railroads, round houses, wyes, sidings, and spur lines shall be inked with their standard symbol. No differentiation will be made between narrow gauge, single track, double track, steam or electric railroads. Abandoned railroads will not be shown. Railroad tunnels will be shown by symbol. Symbols will not be used for railroad stations, since these will be shown as individual buildings.

In inking railroads, the draftsman should use extreme care as to the alignment of tangents and curves. In no case should he depend on freehand work to show this feature, but should always use a triangle or curve to guide him. Ties should be spaced approximately 2/10 of an inch and inked considerably lighter than the main line.

Telephone, Telegraph, & Transmission Lines

There will be only three classes of these lines shown on the planimetric map, and the draftsman will find these

lines clearly identified on the classification sheet. The position of the lines will be shown in pencil on the planimetric map and the draftsman should be guided by these as to the exact location. A telephone line should always be drawn as a separate symbol. In no case should the dots of a telephone line symbol be drawn on the sides of a road as shown on our 1/2 inch base maps. It may sometimes be necessary to exaggerate a symbol slightly to clarify it from other detail. In rare occasions, a telephone line will meander from one side of the road or trail to the other. In this case it is necessary to show the telephone line symbol in a meandering course and crossing over the road or trail. Care should be taken to make the dots of this symbol small and round so that they will not be confused with buildings.

Drainage

Water courses will be shown as follows: namely, large rivers, streams, intermittent streams, and ditches or canals. Large rivers will be shown by a double line, each bank being a direct copy of the pencil draft and should be inked freehand. In no case should a ruling pen or railroad pen be used. Where a river is of sufficient width that the scale will permit water lines, the standard method for water lining should be used.

Streams: The draftsman will find that all streams have been classified on the classification sheet with blue ink indicating that these streams should be inked continuous.

He shall use his best skill and ability to taper the weight of of the stream line from its origin to its mouth. This should be done by using various freehand pens and never with a ruling pen.

Intermittent Streams: These will be shown with the intermittent stream symbol. The draftsman will find that all streams on the penciled map are in solid lines. He must therefore refer to the classification sheet and any stream not classified in blue ink becomes an intermittent stream. Here again, the draftsman should exervide his skill in using a freehand pen for making lines and dots and tapering their weight to give the stream character. Extreme care must be taken in inking the junctions of these streams with solid lines and never by dots.

Ditches or Canals: Only those clearly labeled on the classification sheet will be inked. Their exact locations are indicated on the pencil map in a solid line. These lines should be inked with a ruling or contour pen and should have a smooth course. The draftsman should follow the copy exactly, labeling "ditch" or "canal" whichever the case may be.

Lakes, Reservoirs, & Ponds

The draftsman will find these clearly classified on the classification sheet as to whether they are lakes or intermittent lakes. In indicating these features, waterline any lake or pond of sufficient size that will permit doing so. The draftsman will encounter cases where lakes or

reservoirs have a shore line indicating a lake within an intermittent lake. In this case the two symbols must be used. All shore lines of lakes and waterlining should be done freehand. Cross-hatching of intermittent lakes should be inked with a ruling pen. All section lines must be broken at lake and reservoir shores and will not be inked through waterlining. However, they will be projected through intermittent lakes. Meridian lines are inked through all lakes but should be broken for lettering.

Springs

All springs should be shown by symbol and unless the spring carries a name the word "Spring" or the letters "Spr" should not be inked for identification. It can be identified from the legend.

Falls and Rapids

All falls and rapids will be shown by symbols and no identification should be given other than a geographic name, if one appears on the classification sheet. The draftsman will find these falls clearly marked on the classification sheet and penciled map.

Dams

Dams will be clearly shown on the penciled map, and the draftsman should use the regular symbol for all structures of a small nature. Those appearing on the penciled map in sufficient length and breadth should be inked exactly as outlined.

Glaciers

The draftsman will find all such features clearly outlined on the penciled map and identified on the classification sheet. Boundaries of glaciers should be carefully inked and the standard symbol used.

Washes

Practically all streams of any width, and in some cases intermittent streams, in this Region carry sand washes. These are clearly outlined on the penciled map and the draftsman should ink them with the standard wash symbol. Here the draftsman's skill should be exercised in placing the dots to give the symbol the character required.

Topography

Inasmuch as planimetric maps do not portray the earth's surface in relief, the only topography the draftsman can show are hatchures of hill tops, ridges, bluff lines, and cliffs. These will be clearly indicated in pencil by form lines. The draftsman should follow these form lines precisely when hatchuring these features. Hatchuring should be inked at right angles to form lines.

Sand Dunes

The boundaries of sand dunes will be shown on the penciled map and named on the classification sheet. The draftsman should ink the boundaries with dots somewhat heavier than those inside and use the sand dune symbol throughout the entire area. The draftsman should again exercise his skill and technique to portray this feature clearly.

Boundaries

Exterior Forest Boundaries: These boundaries will be placed on the map by the draftsman and his authority for their position will be taken from the proclamations. The boundaries should be indicated on the map with a light pencil line and checked before the inking is undertaken. The draftsman may use a B-4 speedball pen or regular ruling pen for such lines. Where Forest boundary follows a section or other land line it should be inked with the full width of the line falling on the outer side of the Forest area. Forest boundaries take precedence over all other boundaries and should seldom be broken for lettering. Where a road and boundary follow along the same line, the road in this case take precedence.

Inter-Forest Boundaries: Here again the draftsman will determine the location of these lines from proclamations inasfar as they follow the land grid system. However, where they follow a meandering course along divides or some other feature they will be shown on the penciled map, and the draftsman need only follow the copy using a B-4 speedball pen or a ruling pen. These will be shown by the regular dashed symbol approximately 1/2" in length with 1/10" spacing, and must be equally distributed on each side of the center line of boundary.

Other Boundaries: National or State lines, County lines, City Corporate limits, Reservation lines, and Land Grant lines will be shown according to their respective

symbols. These boundaries take preference in the order listed. The draftsman will follow the classification sheet for the location of all such lines as to whether they fall on section lines or sub-division lines. Where they vary from these they will be shown on the penciled map and the draftsman need only follow the copy, bearing in mind that these lines must be equally centered on the boundary line. Land lines should stop at City Corporate limits.

Section Corners & Lines

These will be clearly shown on the penciled map and the draftsman need only follow the copy. All township, range and section lines should be shown according to symbol chart. Land lines will not be shown in unsurveyed territory. The number of each section should be placed in, or as near as possible, to the center of each section regardless of its size or shape. When a section is split and falls on one or more sheets, letter the number on the sheet having the majority of the section. All found corners must be inked according to the corner symbol as shown on the symbol sheet.

Monuments, Bench Marks, & Triangulation Stations

All monuments, bench marks and triangulation stations must be inked according to standard symbols. These will be clearly located on the penciled map. The classification, numbers, and elevations will be shown on the identification sheet, or in cases of bench marks having numbers, the draftsman will be furnished with a list showing the elevations of each. Extreme care must be

taken to avoid eliminating pertinent detail in placing and inking this lettering on the map.

Buildings

All buildings will be shown by the building symbol. The draftsman will follow the classification sheet for all buildings which, of course, will appear on the penciled map in their proper position and shape.

Mines

The planimetric maps will not show prospect holes, small abandoned mines, shafts, mine tunnels, or small quarries. Unless the mine has a name, the only identification of it will be the exact location and shape of buildings, railroad tracks, if any, and mine dump if of sufficient size to show with hatchures. These features will be clearly marked on the penciled map and the draftsman should use extreme care in making them legible. If the mine has a name it will be labeled on the classification sheet and subsequently inked on the map.

Sawmills

Only permanent sawmills will be shown on planimetric maps and they will be shown by a building symbol only. No consideration will be given to temporary or portable mills. Should no name occur on the classification sheet, the word "Sawmill" should be lettered.

Oil and Gas Wells

The draftsman will find that all such wells will be located on the penciled planimetric map and they should be

shown by the regular symbol. Where wells occur in large groups the boundary of field will be shown and the name of the oil or gas field lettered. The name will appear on the classification sheet.

Fences and Corrals

The draftsman will find that all fences have been shown on the penciled map primarily to aid in compiling land lines. These should not be inked as they will be iliminated from the final map.

The only corrals to be shown are those separated from buildings by a considerable distance and indicated by the field inspector as a general land mark. They will be identified by the corral symbol only, unless definitely named or outlined on the classification sheet.

Airway Beacons

The draftsman will find that all airway beacons have been located on the penciled planimetric map. These will be shown in five classes; namely, airway light beacons, airway light beacons flashing, airway light beacons with code light, land mark light beacons with bearing projector, and land mark light beacons without bearing projector. The designated symbols for these, as shown on the symbol sheet, will be used.

Airports

All airports (unless otherwise restricted by military regulations) will be shown regardless of whether they are of a permanent or temporary nature, improved, or emergency fields. However, the only classification of these will be that all un-

improved, emergency, or temporary airports will be shown by their boundaries, if any, and the word "Airport" lettered. Permanent airports will be shown by their boundaries and improved runways. The word "Airport" with its name will be lettered within the boundary if possible. The draftsman will find this data is clearly marked on the penciled planimetric map and identified on the classification sheet.

Control Tracing

Drafting will prepare a tracing showing the location of photographs and all control before the planimetric sheet goes to the machine transfer room. There will be a tracing for each half, or two tracings per quadrangle. Lettering of point and picture numbers will be done freehand. The latitude and longitude lines and title will be lettered with LeRoy equipment, following the standards on the chart.

Photo-Index Numbers

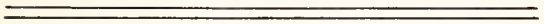
Drafting will prepare a tracing showing the photograph numbers in their proper positions. The tracing is prepared from photostats of the control tracing reduced to the size of the published quadrangle. The number and name of the quadrangle should be placed in the lower right-hand corner of the tracing, using the same guide and pen. This index is printed in blue, in reverse, on the back of each quadrangle so that the location of individual photographs may be easily found by holding the map before a light.

Checking

When the quadrangle has been completed in final form, it shall be thoroughly checked by the Chief Draftsman. He may assign an assistant to aid in this important detail to eliminate the possibility of any oversight. He will make any corrections on a vellum overlay and return it to the draftsman for completion.

SYMBOL SHEET

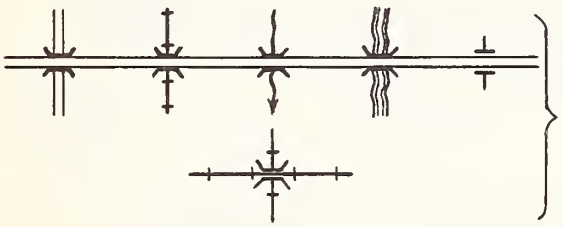
Federal or state highway system



Good motor road

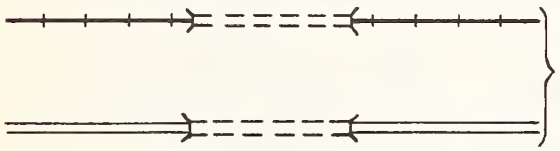
Poor motor road

Trail

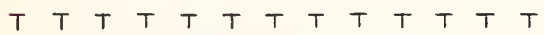


Bridges and culvert

Railroad

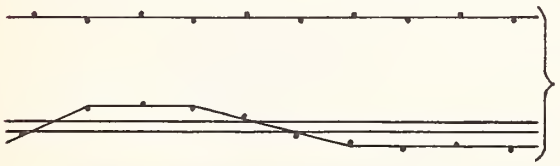


Tunnels

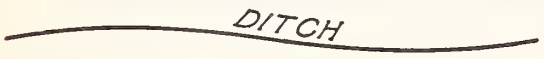


Telegraph line

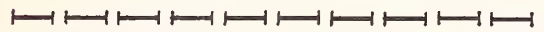
Transmission line



Telephone lines

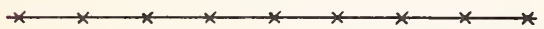


Ditch or canal



Pipe line

Flume



Fence

SYMBOL SHEET

Federal highway marker

State highway marker

Supervisor's headquarters

District ranger station

Guard or ranger station not permanently occupied

Headgate

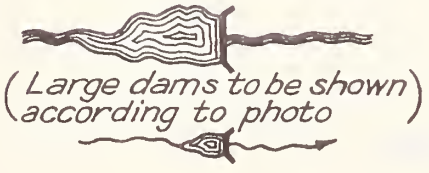
Weather station or tower

House, cabin or other building

Schoolhouse

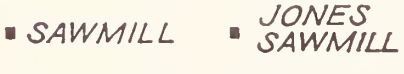
Church

Cemetery



Dams

Mine or quarry, and mine dump

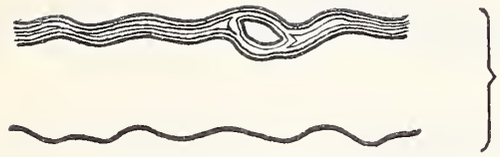


Sawmill

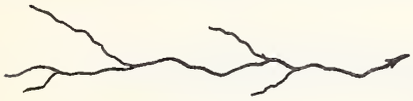
Oil well or field

Corral

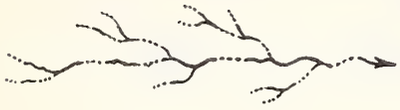
SYMBOL SHEET



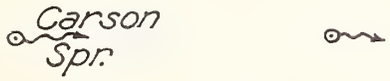
Rivers



Stream



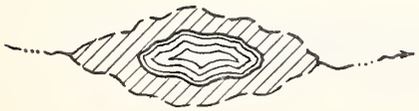
Intermittent stream



Spring

Lake, pond and reservoir

Intermittent lake



Intermittent lake or reservoir

Large and small falls, and rapids

Glacier

Bluffs and cliffs

Ridge

Mountain peak

Intermittent stream and sand wash

Stream and sand wash

Sand dunes

Airway light beacon (arrows indicate course lights).

Airway light beacon, flashing

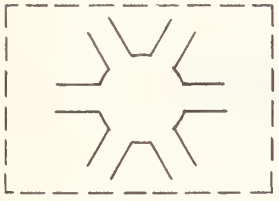
SYMBOL SHEET

Airport light beacon with code light

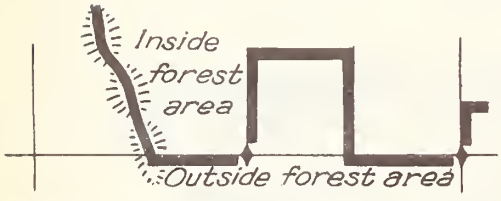
Landmark light beacon with bearing projector

Landmark light beacon without bearing projector

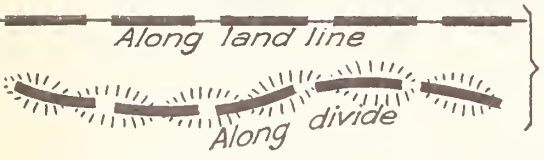
Emergency airport



Improved airport



National forest boundary



Inter-forest boundary

National, state or province line

County line

City corporate limit. boundary

Land grant line

Reservation line (Indian, military national park or national monument)

Township line

Section line

Boundary monuments

SYMBOL SHEET

Section corner

C. and G.S. or U.S.G.S. triangulation station

U.S.F.S. P-50 — Forest Service fourth order control station

Triangulation station and permanent lookout station

Permanent lookout station

B.M. 6250 — Permanent bench mark and elevation

6250 — Supplementary bench mark and elevation

APPROXIMATE SIZES OF LETTERING

NORTH PLATTE RIVER
YELLOWSTONE LAKE
} *Large rivers or lakes*

Canadian River
Buffalo Creek
Chambers Lake
} *Small rivers, large creeks, and fairly large lakes*

Pinto Creek *Mexican Creek,*
Rainbow Lake, *Gilpin Spring*
} *Small creeks, lakes ponds and named springs*

Unaweep Canyon,
Long Draw, East Mesa,
Arapaho Pk., Antelope Pass
} *Canyons, gulches, draws, mountain peaks, buttes, mesas and passes*

UNION PACIFIC R. R., *UTE TRAIL,*
BLAINE MINE, *BARNES RESVR,*
STUB CR. R.S., *JACKSON SAWMILL*
} *Culture*

SYMBOL SHEET

PUEBLO, FORT COLLINS, GREELEY, TRINIDAD } *Cities or towns of 10000 population or over*

Cowdrey P.O., LaVeta P.O., Salida, Northgate } *Towns or post offices under 10000 population*

S E C T I O N K

M.P CORRECTIONS

GENERAL

It is realized that no matter how accurately a map is made, corrections will be necessary from time to time; therefore, the following procedure has been set up for correcting planimetric maps made from aerial photographs, and in no case will corrections be added to this map through any other procedure. There is nothing that can destroy the accuracy of maps and the confidence of the map users more quickly than adding erroneous and indefinite corrections; and if such a policy is followed, the map soon becomes a picture without a foundation and entirely useless from an accurate map standpoint.

Field Corrections

When the field inspector makes his inspection he carefully delineates any corrections or additions on the set of photographs he has with him. The prints are returned to the office of Surveys and Maps where all corrections and additions are transferred to the detail set of photographs in red ink and are then added to the planimetric map. This all takes place before the final drafting and publication of the quadrangle.

Future Corrections

Since it is necessary to add future corrections to all planimetric maps, our chief source for this information will be that of the Forest Supervisors and Rangers, Range and Timber Survey crews, or such other parties covering the area that has been mapped. The Forest Supervisor will be re-

quested to send map corrections on his Forest to the office of Surveys and Maps each year. His corrections will be sent in on the Ranger's set of photographs which will be returned after the information has been transferred to the detail pictures. Photographs used by Range Surveys, Timber Surveys, or any other parties working in the field on photographs will be studied when available, for map corrections. Any data taken from these photographs will be transferred to our detail prints.

All such corrections will be outlined with a red pencil on the planimetric quadrangle bound in atlas form in the file room and kept for corrections only, with a note as to the number of the photograph involved and the source of information. This detail will then be transferred in red to the detail set of photographs, and the Supervisor's or Survey prints will be returned to their rightful owners. This will make available information in the office of Surveys and Maps at all times, all corrections necessary to be made for each planimetric quadrangle. When such quadrangles are up for correction or publication, all that will be necessary for the cartographer to do will be to take the atlas sheets pertaining to the quadrangle to be corrected and secure from the files the detailed prints involved and add this information to the planimetric sheet in the same manner as it was originally compiled.

This information, as received from time to time, gives an excellent study for the cartographer on any errors made in compiling planimetric maps.

S E C T I O N F

PUBLICATIONS

General

All publications of planimetric maps will be done by lithography to a scale of 1:63,360. Since all of the original planimetric sheets are on a scale of 1:31,680 this will mean a half reduction and will give a neat, clean-cut appearance to all detail. All such maps will be published locally but before contracts are let a photostat copy of each quadrangle must be sent to Washington for checking and approval. When bids are issued the following specifications should be used.

Specifications

Printing: Each 30-minute quadrangle map shall be printed on 25% rag content, opaque treated paper, size 30x39". The paper must be cut with the grain in the same direction. The printing must be clear and sharp. A gray black ink must be used instead of a dense black ink. A sample of the color ink must be submitted before the maps are printed.

Scale: Every 30-minute quadrangle map shall be printed on a scale of 1" = 1 mile. The scale of the original map is 2" = 1 mile which means a reduction of 2 to 1. The original map is drawn on paper mounted on metal, it is in two sections with the edges matched perfectly. Each section is 36x60" in size. (The north half and the south half which makes it necessary for the printer to join the two halves by a butt joint which will be made on a parallel line of latitude.)

Lettering: All marginal lettering shall be drafted for the for the printer and furnished to him with the map. All of the marginal lettering and notes shall be photographed separately and stuck up on the offset plate. Full instructions as to the location and size of lettering shall be furnished with each 30-minute quadrangle map. There will be a slight change in some of the numbers and titles on each map.

Joining Plates: When plates are joined together, there shall be no gaps nor offsets in meridian or parallel lines of latitude and longitude. The detail shall match so that the joint will not be noticeable.

Checking: The printer must furnish a proof copy before the final printed copies of the map are made. This proof copy of the printed map shall be carefully checked by the Chief Draftsman. At the intersection of the 15-minute latitude and 15-minute longitude lines, a line shall be projected to each of the four corners of the proof copy. Measurements shall be taken on each of the four lines, also measurements shall be taken N. and S. and E. and W. on the 15-minute latitude and longitude lines including the four outside boundary projection lines. All measurements shall check to 1/2 of the distance ofthe original measurements on the 2" scale map. A variation of not more than 1/32 of an inch over the entire distance of the proof copy shall be permitted. The proof copy shall also be checked to see that there are no foreign lines or

blemishes on it. The lettering and detail on the proof copy must appear as clean as on the original map.

Plates: The plates shall be held by the printer for a period not exceeding five years unless otherwise stated.

Reprints: The printer must quote prices on reprints of the map within a five year period for lots of 100, 500, and 1000 copies.

Printing Numbers on Back of the 1" Scale Printed Copies: The printer shall be furnished a vandyke negative on a 1 inch to a 1 mile scale with all of the aerial photograph numbers and the proper registration marks on it. The vandyke negative shall be made so that it can be used directly to make the lithographic plate which must be so made that all the numbers shall be printed in reverse on the back side of the 1" scale printed maps. When this is done it will be possible to hold the map up to a strong light and read the numbers in their normal position. The numbers shall be printed in a light blue shade of ink so that they can not be distinguished through the map unless it is held up to the light. A sample of the color ink must be submitted before the numbers are printed on back of the one-inch scale printed copies.

Delivery of Printed Maps: The printer shall deliver the final printed copies within ten calendar days after the

receipt of the original maps. The printer shall mail seventy-five printed copies to the Chief, Forest Service, Department of Agriculture, Washington, D. C. The balance of the printed maps, which is generally 925, shall be delivered to Room 463-B Post Office Building, Denver, Colorado.

S E C T I O N O

INDEXING AND FILING

General

The entire Region is laid out on a 30' quadrangle basis coinciding with U. S. Geological Survey 30' quadrangles. In addition to the U. S. Geological Survey names of these quadrangles an index filing number system has been given, starting with number 1 in the southwest corner of the State of Colorado and progressing east and north throughout the Region consecutively. This number system covers far more than is ever anticipated in the scope of the National Forests, and therefore there will be some of these sheets never used.

Film

Aerial film is filed in the can in which it is delivered from the factory. As each roll of film becomes ready for filing, the can is labeled with a label containing information about the roll required by the "Standard Specifications for Aerial Photography, AAP-1101." The rolls are then filed in cabinets designed for this purpose. All rolls of one project are stored together, with the rolls in numerical order within the cabinet. Film of acetate base presents no storage problem, but with film of nitrate base, fire danger must be considered.

Photographs

Two sets of contact prints are made for use in compiling planimetric maps. One set is labeled "Control" and the other set is labeled "Detail." The two sets are filed in exactly the same manner as outlined below:

Prints are filed in units of one quadrangle per drawer. Each quadrangle is first divided into strips (as indicated on the flight map) and pictures for each strip are filed together in numerical order, the strips also being filed in numerical order. Prints for one quadrangle thus occupy two drawers, the control set being filed above the detail set. Radial line templets for a quadrangle are filed by strips in the same manner as control prints and in the same drawer, the templets being grouped behind the control prints.

Prints or templets which have been turned over to the file clerk will be checked out to individuals as follows:

On the front of each drawer are a number of hooks, one hook for each strip. Labels indicate the strip each hook represents. Adjacent to the drawer on the cabinet is a hook representing the entire quadrangle. Each person who checks out prints has a number of tags bearing his name. Prints are checked out in no units smaller than a strip. The person calling for prints calls for the strip desired, giving to the file clerk one tag for each strip or for the entire quadrangle if it is desired. The file clerk obtains the prints desired and hangs upon the appropriate hook the name tag for the material checked out. No person is allowed to take out or replace material belonging in the files except the file clerk. This system enables material to be checked out and in with a minimum of time spent in the file room and a minimum of written records which take up the time of the file clerk. The tags on the drawer fronts indicate to the file clerk at a glance which prints are checked out and in

whose possession they should be.

Timber and grazing prints are filed by rolls. The prints for each roll are in numerical order and rolls are filed in numerical order throughout the project without regard to geographical location.

Control Tracings

Each half of every quadrangle sheet has a control tracing which are filed in numerical order in a specially designed cabinet having rods running across the top of the cabinets. Control tracings are hung from the rods by means of three cello-clips attached to each tracing. The cello-clips are easily slipped on or off the rods. Above each control tracing is a hook upon which may be hung the name tag of the person checking it out.

Quadrangle Sheets

Quadrangle sheets are filed in numerical order in a specially designed cabinet having slots running from front to rear of the cabinet. Each quadrangle sheet is suspended from two hangers which are detachable from the control sheet and which slide in the slots in the filing cabinet. Above each quadrangle sheet is a hook upon which is hung the name tag of the person checking out the sheet.

Triangulation Sheets

Triangulation sheets are filed in a specially designed cabinet which has slots in the top and bottom into which the sheets fit and which maintain the sheets in a

vertical position. Each slot is numbered to correspond with its triangulation sheet and above each slot is a hook to receive the name tag of the person who checks it out.

Printed Quadrangle Sheets

Printed quadrangle sheets are filed in drawers of proper size in numerical order. A supply of printed maps is kept in the file room with a larger reserve stock in filing cabinets in B-71 stock room.

Triangulation & Traverse Stations

A card file will be kept in the office of Surveys and Maps for each triangulation station showing its location by latitude and longitude and description. This card file will be for U. S. Geological Survey, U. S. Coast and Geodetic Survey, and Forest Service stations located. In addition to card files there will be a mimeographed pamphlet bound showing station, by whom occupied, date, latitude and longitude position, and full description. This pamphlet will be bound by quadrangles showing all monumented stations within said quadrangle. Copies of this pamphlet will be given after quadrangle sheet is published to Forest Supervisor's Office, Forest Ranger, and such other activities as demand the use of these, samples of which are shown on pages 0-7-12 Inclusive.

Elevations - B.M's. & T.B.M's.

There will be a card record in the office of Surveys and Maps of all B.M's. and T.B.M's.; also there will be a mimeographed pamphlet by quadrangles the same as for triangulation and traverse stations, a sample of which is on Page 0-13.

Photographic Coverage of Each Section by Townships

When map compilation is completed, a photographic record of each section will be made up in a mimeographed pamphlet form covering an entire quadrangle, samples of which are shown on Pages 0-14. This pamphlet will serve to locate a photograph of any given section on quadrangle. Each Forest Supervisor and Ranger will be given a copy of this pamphlet for their files; also any other Forest activity interested in any particular quadrangle will be furnished with a copy.

This index is so arranged that anyone examining the planimetric map and wishing to find out what photographs cover any given area all that is necessary is to look on margin of sheet, determine township and range, and then locate what section. After this is done he turns to pamphlet and in top heading he finds Township and Range and in extreme left column he finds sections. By following this out he will find the principal photograph covering this section and also all adjacent photographs.

Location of Each Photograph by Section and Township

This will be mimiographed in the same manner as the preceding index and will cover the same area. A sample of this index is given on pages0-15. The difference in these two indexes is that if anyone picks up a photograph and wishes to know its exact location on planimetric maps he will look at the number in the northeast corner of the

photograph. For example: Photograph No. 5-10 - turning then to this index he will see that this photograph is located in Sections 29 and 30 of Township 11 North 79 West. Copies of this index will be furnished in the same manner as previous one.

SHIPMAN
U.S.G.S. DATE

Larimer-Jackson Counties, Colo.

1927 North American Datum

Latitude - 40° 49' 42.416" Longitude - 106° 04' 38.542"

On the Medicine Bow Range about 1.5 miles north west of the Ute Pass where the State road to Walden crosses the Medicine Bow Range 15 miles east of Walden. Station is on the first high point northwest of the Ute Pass and is probably on the line between Larimer and Jackson Counties. It can be easily reached by following ranger's trail from Ute Pass to Village Belle mine. Wycola Trail leaves the State road at firebox 46 in the pass and runs within a few feet of the station.

Signal: A six-sided pole signal carrying white and black flags with white on sides and pine bushes at apex.

Station Mark: Standard bench mark tablet set in solid rock, centered under signal.

To Station	Azimuth			Back Azimuth			Distance Log. Meters	Miles
Walden Standpipe	56°	58'	21.00"	236°	50'	31.00"	4.30454	12.53
Jelm	195	50	32.61	15	54	30.39	4.4914620	19.267
Red	213	05	13.13	33	10	50.13	4.3430520	13.690
Bull	244	09	04.38	64	18	38.45	4.3577621	14.162
Little Bald	262	51	18.62	83	03	53.90	4.4355270	16.939
North Bald	280	13	20.33	100	28	11.10	4.5114089	20.172
South Bald	284	30	44.73	104	45	52.73	4.5225470	20.697
Hague	316	10	02.43	136	26	54.49	4.7228605	32.825
Rawah	331	08	00.8	151	12	46.4	4.33125	13.33
Clark	333	01	12.02	153	06	59.48	4.4409279	17.151
Richthofen	338	42	24.43	158	49	33.89	4.6311193	26.575

WALDEN STANDPIPE Date
U. S. G. S.

Jackson County, Colo. (Not Occupied.)

1927 North American Datum

Latitude - 40° 43' 45.5" Longitude - 106° 16' 38.9"

Standpipe in the town of Walden.

Signal and station mark: Center of standpipe. Signed from two stations; position doubtful.

To Station	Azimuth	Back Azimuth	Log. Meters	Distance Miles
Shipman	236° 50' 31"	56° 58' 21"	4.30454	12.53
Richthofen	311 31 53	131 46 51	4.63765	26.97

STATION NO. 1 Date 1937
U. S. F. S.

JACKSON COUNTY
Accuracy - 4th Order Plane Table
1927 North American Datum

Latitude - 40° 48' 24.5" Longitude - 106° 16' 41.1"

The station lies 5 miles, airline, north of Walden and about 1 mile east. To reach station follow the road from Walden to Cowdry for about 4-1/2 miles north until reaching the sign on the road pointing to the east which says "Brownlee Oil Lease No. 1." Proceed along the road in a northeast direction around hill to a point where the road turns almost directly west. From this point on the road the station is 150 feet northeast. The station is located on the high point of the ridge and about 300 feet east of the section line. There is a 1/4 section corner between Sections 28 and 29 which lies on the brim of a hill about 500 feet northwest. Car can be driven to station.

Signal: Quadrapod of sawed lumber with target on sides and red and white flag centered over monument.

Station Mark: Standard Forest Service bench mark tablet set in a 5" diameter concrete post set flush with the ground.

Station	Distance in Miles	True Compass Bearing
No. 9	6.3	N. 7° 40' E.
No. 39	9.67	N. 28° 30' E.
No. 40	8.33	N. 53° 25' E.
No. 8	4.64	N. 60° 10' E.
Shipman	10.6	N. 81° 55' E.
No. 7	5.4	S. 81° 55' E.
No. 2	6.66	S. 41° 35' E.
No. 18	11.88	S. 25° 30' E.
Walden	5.35	S. 0° 15' E.
No. 4	8.5	S. 29° 10' W.
No. 6	5.86	S. 56° 25' W.
No. 37	8.65	S. 85° 15' W.
No. 11	11.6	N. 64° 0' W.
No. 26	11.8	N. 51° 05' W.
No. 23	8.8	N. 36° 40' W.
No. 30	4.1	N. 26° 35' W.
No. 34 A-2	9.16	N. 9° 15' W.
No. 34	8.74	N. 2° 25' E.

STATION NO. 2 Date 1937
U. S. F. S.

JACKSON COUNTY
Accuracy - 4th Order Plane Table
1927 North American Datum

Latitude - 40° 44' 3.5" Longitude - 106° 11' 39"

To reach station take the road which leads from center of town of Walden directly to the east. Proceed along this road for three miles to a point where the road takes a bend to the north. At this point a large flat topped sage brush hill can be seen about 3/4 of a mile directly ahead. Station is set on the high point of this hill. Car can be driven to station.

Signal: Quadrapod of sawed lumber with target on sides and red and white flag centered over monument.

Station mark: Standard Forest Service bench mark tablet set in 5" diameter concrete post set flush with ground.

Station	Distance in Miles	True Compass Bearing
No. 7	4.35	N. 12° 20' E.
Shipman	8.9	N. 43° 15' E.
No. 12	10.7	S. 82° 35' E.
No. 17	8.3	S. 40° 00' E.
No. 18	5.75	S. 7° 00' E.
No. 22	10.38	S. 15° 00' W.
No. 3	6.4	S. 22° 20' W.
No. 4	8.92	S. 51° 25' W.
Walden	4.38	S. 62° 25' W.
No. 21	16.65	N. 81° 05' W.
No. 6	9.48	N. 79° 15' W.
No. 10	13.55	N. 53° 55' W.
No. 1	6.67	N. 41° 25' W.
No. 30	10.7	N. 35° 50' W.
No. 9	11.8	N. 17° 30' W.

STATION NO. 3 DATE 1937
U. S. F. S.

JACKSON COUNTY
Accuracy - 4th Order Plane Table
1927 North American Datum

Latitude - 40° 40' 8.5" Longitude - 106° 16' 50"

To reach station take the road from Walden to Willow Creek Pass. From the town of Walden it is about 2½ miles along this road to a point where there is a gate on the east side of the road. Turn through this gate to the east and follow the old road to the south through three wire gates. After passing through the third gate turn sharply to the east along fence. About a half mile from the last gate to the east there will be found an old buffalo wallow which at the present time is a dry lake. The station lies only 500 feet northeast of this point and on the top of a very small rise.

Signal: Quadrapod of sawed lumber with target on sides and red and white flag centered over monument.

Station Mark: Standard Forest Service bench mark tablet set in a 5" diameter concrete post set flush with the ground.

Station	Distance in Miles	True Compass Bearing
Walden	4.15	N. 2° 15' E.
No. 2	6.4	N. 45° 20' E.
No. 18	5.4	S. 77° 00' E.
No. 19	7.87	S. 44° 55' E.
No. 5	6.98	S. 87° 25' W.
No. 13	11.03	N. 78° 10' W.
No. 10	14.03	N. 27° 10' W.
No. 4	4.53	N. 62° 40' W.

STATION NO. 4 DATE 1937
U. S. F. S.

JACKSON COUNTY
Accuracy - 4th Order Plane Table
1927 North American Datum

Latitude - 40° 41' 58" Longitude - 106° 21' 26"

To reach station take the road from Walden to Muddy Creek Pass about 6½ miles southwest of the town of Walden and at the end of the tangent on the road. This tangent being 5 miles long. There is a long ridge which runs from the northwest to the southeast. Station is located about 1 mile northwest of this point on the road. At the end of this tangent there is also a road which turns back to the northwest which can be used to reach station. To reach station follow this road from the end of the tangent for about 1 mile, then turn up hill sharply to the west. Station is located on the top of rocky hill.

Signal: Quadrapod of sawed lumber with target on sides and red and white flag centered over monument.

Station Mark: Standard Forest Service bench mark tablet set in a 5" diameter concrete post set flush with ground.

Station	Distance in Miles	True Compass Bearing
No. 1	8.5	No. 29° 15' E.
Walden	4.68	N. 63° 40' E.
No. 2	8.92	N. 74° 10' E.
No. 3	4.54	S. 62° 35' E.
No. 22	9.63	S. 37° 55' E.
No. 32	4.68	S. 29° 45' E.
No. 5	3.8	S. 50° 40' W.
No. 13	6.78	N. 88° 55' W.
No. 21	9.3	N. 57° 59' W.
No. 6	4.25	N. 10° 00' W.

ELEVATIONS & DESCRIPTIONS

B. M's. and T. B. M's.

No elevation data on hand at present.

TOWNSHIP 9 NORTH, RANGE 79 WEST

SIXTH PRINCIPAL MERIDIAN

Section	Principal Photograph	ADJACENT PHOTOGRAPH TOUCHING ON THE North	South	East	West
1	6-43	6-44	6-42	6-76	-----
2	6-43	6-44	6-42	----	5-109
3	5-109	5-110	5-108	----	-----
4	5-109	5-110	5-108	----	5-17
5	5-17	5-16	5-18	5-109	-----
6	5-17	5-16	5-18	-----	-----
7	5-19	5-18	5-20	-----	-----
8	5-19	5-18	5-20	5-107	-----
9	5-107	5-108	5-106	-----	5-19
10	5-107	5-108	5-106	6-42	-----
11	6-42	6-43	6-41	-----	5-107
12	6-42	6-43	6-41	6-78	-----
13	6-41	6-42	6-40	6-78	-----
14	6-41	6-42	6-40	-----	5-106
15	5-106	6-107	6-105	6-41	-----
16	5-106	6-107	6-105	-----	5-20
17	5-20	5-19	5-21	5-106	-----
18	5-20	5-19	5-21	-----	-----
19	5-21	5-20	5-22	-----	-----
20	5-21	5-20	5-22	5-105	-----
21	5-105	5-106	5-104	-----	5-21
22	5-105	5-106	5-104	6-40	-----
23	6-40	6-41	6-39	-----	5-105
24	6-40	6-41	6-39	6-79	-----
25	6-39	6-40	6-38	-----	-----
26	6-39	6-40	6-38	-----	5-104
27	5-104	5-105	5-103	6-39	-----
28	5-104	5-105	5-103	-----	5-22
29	5-22	5-21	5-23	5-104	-----
30	5-22	5-21	5-23	-----	-----
31	5-23	5-21	5-24	-----	-----
32	5-23	5-21	5-24	5-103	-----
33	5-103	5-104	5-102	-----	5-23
34	5-103	5-104	5-102	6-38	-----
35	6-38	6-39	6-37	-----	5-103
36	6-38	6-39	6-37	-----	-----

Location of Each Photograph by Section and Township

Photo No.	Section	Township	Range Range	Photo No.	Section	Township	R Range
5-3	19 - 20	12 N.	79 W.	5-25	7	8 N.	79 W.
5-4	29 - 30	12 N.	79 W.	5-25	12	8 N.	80 W.
5-5	31 - 32	12 N.	79 W.	5-26	18	8 N.	79 W.
5-6	5 - 6	11 N.	79 W.	5-26	13	8 N.	80 W.
5-7	7 - 8	11 N.	79 W.	5-27	19	8 N.	79 W.
5-8	17 - 18	11 N.	79 W.	5-27	24	8 N.	80 W.
5-9	19 - 20	11 N.	79 W.	5-28	30	8 N.	79 W.
5-10	29 - 30	11 N.	79 W.	5-28	25	8 N.	80 W.
5-11	31 - 32	11 N.	79 W.	5-29	31	8 N.	79 W.
5-12	5 - 6	10 N.	79 W.	5-29	36	8 N.	80 W.
5-13	7 - 8	10 N.	79 W.	5-30	6	7 N.	79 W.
5-14	17 - 18	10 N.	79 W.	5-30	1	7 N.	80 W.
5-15	19 - 20	10 N.	79 W.	5-31	7	7 N.	79 W.
5-16	29 - 30	10 N.	79 W.	5-31	12	7 N.	80 W.
5-17	31 - 32	10 N.	79 W.	5-32	18	7 N.	79 W.
5-18	5 - 6	9 N.	79 W.	5-32	13	7 N.	80 W.
5-19	7 - 8	9 N.	79 W.	5-33	19	7 N.	79 W.
5-20	17 - 18	9 N.	79 W.	5-33	24	7 N.	80 W.
5-21	19 - 20	9 N.	79 W.	5-34	30	7 N.	79 W.
5-22	29 - 30	9 N.	79 W.	5-34	25	7 N.	80 W.
5-23	31 - 32	9 N.	79 W.	5-35	31	7 N.	79 W.
5-24	6	8 N.	79 W.	5-35	36	7 N.	80 W.
5-24	1	8 N.	80 W.				